DOCUMENT RESUME

ED 396 106 CE 071 769

TITLE	Marine Science Careers. A Sea Grant Guide to Ocean Opportunities.
INSTITUTION	Maine Univ., Orono.; New Hampshire Univ., Durham.; Woods Hole Oceanographic Inst., MA.
SPONS AGENCY	National Oceanic and Atmospheric Administration (DOC), Rockville, Md. National Sea Grant Program.
REPORT NO	ISBN-0-9649529-0-4; NHU-E-96-001; WHOI-E-96-001
PUB DATE	96
NOTE	45p.
AVAILABLE FROM	Sea Grant Communications, Kingman Farm, University of New Hampshire, Durham, NH 03824-3512 or Sea Grant Communications, 193 Oyster Pond Rd., CRL 209, Woods Hole, MA 02543-1525 ($5).
PUB TYPE	Reference Materials - Directories/Catalogs (132)
EDRS PRICE	MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS	Annotated Bibliographies; *Career Choice; Career Development; Career Education; *Educational Needs; *Employee Attitudes; *Employment Opportunities; *Employment Qualifications; High Schools; High School Students; Job Satisfaction; Marine Biology; *Marine Education; Marine Technicians; Oceanography; Scientific Personnel

ABSTRACT

This document, which is intended for high school students who are considering a marine science career, contains 38 profiles of individuals employed in one of the following occupations: marine biologist, environmental educator, fishery biologist, marine ecologist, aquaculture microbiologist, geological oceanography, environmental consultant, ocean modeler, chemical oceanographer, aquatic chemist, physical oceanographer, biological oceanographer, ocean engineer, civil engineer, electrical engineer, environmental engineer, aquatic engineer, naval architect, ocean advocate, marine educator, underwater filmmaker, marine archaeologist, marine economist, lifeguard, fisheries statistician, resource manager, and environmental communicator. Each profile contains the individual's responses to a questionnaire requesting information on the following: degrees held/working toward, schools attended, current job and job duties, key factor in career decision, most and least appealing aspects of the job, preferred leisure activities, heroes/heroines, advice to high school students interested in the same job, career opportunities in the field, and plans for 10 years from now. Also included are the following: discussion of the outlook for marine science careers; annotated bibliography of 12 resource organizations and 5 publications; and names and addresses of 32 sea grant programs. (MN)

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Marine Science Cur

A Sea Grant Guid

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Cover photos, left to right: University of Delaware oceanographers Xiao-Hai Yan (right) and Vic Klemas have developed a computer program that can analyze real-time satellite images of the Delaware and New Jersey coasts and quickly determine how fast sea-surface currents are moving. Isabelle Kay, a marine biologist with the Scripps Institution of Oceanography, examines eelgrass beds in San Diego's Mission Bay. Divers work to recover ABE (Autonomous Benthic Explorer), a device built by ocean engineers at the Woods Hole Oceanographic Institution with support from the National Science Foundation to help carry out deep-sea explorations around the world.

Additional copies of this publication are available from many of the Sea Grant programs listed on page 40 or for $5 a copy from either the Sea Grant Communications Office at the University of New Hampshire (Sea Grant Communications, Kingman Farm/UNH, Durham, NH 03824-3512 — checks payable to UNH) or the one at the Woods Hole Oceanographic Institution (WHOI Sea Grant Communications, 193 Oyster Pond Road, CRI, 209, Woods Hole, MA 02543-1525 — checks payable to WHOI).

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ISBN 0-9649529-0-4

NHU-E-96-001
WHOI-E-96-001

This publication was made possible by the National Sea Grant College Program of the National Oceanic and Atmospheric Administration, Department of Commerce. The views expressed herein do not necessarily reflect the views of any of those organizations.

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NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NOAA
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Marine Science Careers

A Sea Grant Guide to Ocean Opportunities

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Introduction

Students thinking about careers in the marine sciences often picture themselves working with whales. Within the marine science fields, however, very few scientists specialize in that area. This career guide will introduce you to a wide range of marine career fields and to people working in those fields. In addition, the guide will give those men and women a chance to tell you what they like and dislike about their careers, what they see for the future in their fields, and much much more.

Before we get to that, though, we'd like to introduce Sea Grant, the guide's sponsor. A component of the National Oceanic and Atmospheric Administration (NOAA), the National Sea Grant College Program is a federal-state partnership. It supports marine-related research, education, and advisory activities. These activities help us learn more about our marine resources and improve how we use them. Sea Grant operates through a network of academic and research institutions located in our coastal and Great Lakes states as well as in Puerto Rico. The 29 state and regional Sea Grant programs (see page 40) are good sources of marine-related information. Don't hesitate to contact them.

As noted earlier, Sea Grant operates in the Great Lakes states as well as in the ocean states. The guide reflects that by including profiles of several people whose careers involve those lakes rather than the oceans. Because the Great Lakes and the oceans are similar in many ways, scientists studying them face similar challenges.

The guide includes four career sections. The first is marine biology. Scientists in this field study the behavior and ecology of plants and animals that live in the ocean and their roles in the marine food chain. They also study the effects of pollution on the marine environment.

Be flexible. It's fine to opt for a marine science career at an early age, but it's a mistake to decide your exact specialty before you've had a chance to explore your options.

The second section deals with oceanography and the different types of oceanographers. Geological oceanographers study the evolution of the ocean bottom and the nature of the minerals found there. Chemical oceanographers study the chemicals and chemical compounds in the oceans. Physical oceanographers study the ocean as mass in motion, from the gentle movements of ocean currents to the dramatic power of tidal waves.

The third section focuses on ocean engineering. It covers the work of those who design and build the instruments, equipment, vehicles, and structures used in the marine environment. While these three sections divide marine scientists into distinct groups, marine research brings them together. To find the answers to their questions, scientists regularly seek the expertise and assistance of those in other fields.

The fourth section of the guide contains information on careers that are not traditional marine science careers, but relate to them in one or more ways. Among the people profiled there you will find an underwater filmmaker, a marine economist, a research vessel captain, and a resource manager.

The people featured in the guide cover a wide range in many ways. Some work at colleges and universities. Others work for state and federal agencies, marine-related industries, research laboratories, independent organizations, or consulting firms. They come from all around the country and represent a variety of educational backgrounds. Some are in the early stages of their careers while others are well established in theirs.

Marine Science Careers Questionnaire

1. *What degrees do you hold (or are you working toward) and from what schools?*
2. *What is your current job and what does it entail?*
3. *What was the key factor in your career decision?*
4. *What do you like most about your career?*
5. *What do you like least about your career?*
6. *What do you do to relax?*
7. *Who are your heroes/heroines?*
8. *What advice would you give a high school student who expressed an interest in pursuing a career in your field?*
9. *Are career opportunities in your field increasing or decreasing and why?*
10. *What will you be doing 10 years from today?*

We asked each a set of questions (see box) designed to meet the information needs of students with an interest in marine careers. We've printed their answers, allowing them to profile themselves.

The final section of the guide deals with a very critical subject, especially if you are fascinated by the first four sections and convinced that a marine science career is for you. That section examines the future needs for people in these fields. It contains good news and bad news, and the educated guesses of those who are in the best position to make projections. At the end of the career outlook section, you will find a list of additional resources. While by no means inclusive, this list of organizations and publications should help you in your search for additional information.

One thing you won't find in this guide is salary information. Salaries tend to vary widely in scientific fields depending upon employer, specialty, location, and many other factors. Information on salary levels should be available from your school's guidance department. Another thing you won't find are any hard-and-fast rules about how many years of education are required for a particular position. Educational requirements vary, and you will find people in the guide with similar jobs but different educational backgrounds. You will also find people working in their chosen career and working towards a higher degree at the same time. They realize that education is a lifelong experience and are seeking to increase their opportunities by increasing their knowledge.

Before you get into the main part of the guide, we have a few words of advice to offer. First, be flexible. It's fine to opt for a marine science career at an early age, but it's a mistake to decide your exact specialty before you've had a chance to explore your options. Second, take advantage of the opportunities that exist to get hands-on experience through marine education programs. Your science teacher or guidance counselor, nearest Sea Grant office, or local chapter of the National Marine Educators Association (NMEA) can help you identify some of these offerings. (To identify the nearest NMEA chapter, contact the national office: PO Box 51215, Pacific Grove, CA 93950, 408/648-4837.) Third, take as many math, science, and computer courses as you can in school. Also, pursue related studies as part of independent studies projects. Fourth, don't expect preparing for a marine science career to be easy. Fifth, don't give up. Good luck.

Steve Adams
Maine/N.H. Sea Grant

Tracey Crago
Woods Hole (Mass.) Sea Grant

Marine Biology

Left to right, marine biologists Marcel Montane and Karen Metcalf and marine science technician Eric Farrar of the Virginia Institute of Marine Science, College of William and Mary, sample for juvenile blue crabs in a Chesapeake Bay grass bed as part of a study of blue crab population dynamics.

The field of marine biology — the study of marine organisms, their behaviors, and their interactions with the environment — is considered one of the most all-encompassing fields of oceanography. To understand marine organisms and their behaviors completely, marine biologists must have a basic understanding of other aspects, or "disciplines" of oceanography, such as chemical oceanography, physical oceanography, and geological oceanography. Therefore, marine biologists and biological oceanographers study these other fields throughout their careers, enabling them to take a "big picture" approach to doing research.

In reading about marine biology and each of the other fields, keep in mind that some of the most important oceanographic discoveries have been made as a result of an integrated, multidisciplinary approach, often involving geologists, chemists, biologists, physical oceanographers, and engineers.

Specializing within the Field

Because there are so many topics one could study within the field of marine biology, many researchers select a particular interest and specialize in it. Specializations can be based on a particular species, organism, behavior, or ecosystem. For example, marine biologists may choose to study a single species of clams, or all clams that are native to a climate or region. Others may choose to study a disease that is causing serious problems for a particular species.

Probably the topic most often asked about within this field of research is marine mammals, including cetaceans (whales and dolphins) and pinnipeds (sea lions, seals, and walruses). Due to the popularity of marine mammals at aquaria and marine centers, as well as that of movies, television shows, and books about whales and dolphins, researchers in this field are overwhelmed with requests from students and the public about what it takes to become a marine biologist and to work with marine mammals.

Research jobs involving marine

mammals are extremely hard to come by for a number of reasons, including the popularity of the field, the fact that working with marine mammals is highly regulated, and because funding is very competitive. There are two popular fields of study involving marine mammals. One is bioacoustics and vocalization, the study of marine mammal sounds to learn how they communicate, and how they produce, perceive, and respond to sounds. The other is population dynamics, which includes the study of marine mammalian behaviors such as feeding, reproduction, and migration, and understanding how these behaviors affect the number of whales in the oceans and how they may be altered by environmental disturbances. Another career path for those interested in working with marine mammals would be working in an aquarium or museum. Also, careers with national and international conservation groups are possibilities in this area.

Some marine biologists choose to specialize in a particular environment, habitat, or ecosystem, for example: wetlands, mangroves, or salt marshes. Using salt marshes as an example, one could study several different species of fish and shellfish, aquatic plants, and birds that live in a particular salt marsh, as well as other factors that affect the salt marsh ecosystem. This is where the importance of understanding and working with scientists from other fields, such as chemical, geological, and physical oceanography and terrestrial ecology and hydrology, comes in handy. Understanding the interaction within a system helps us learn how to protect it and make the right regulations.

Another area of specialization, the emerging field of marine biotechnology, offers great opportunity for marine biologists. Like others, this field involves working with researchers from other disciplines. For example, researchers in the field of marine biotechnology have identified new sources of drugs, such as manoalide, an anti-inflammatory and analgesic (pain relieving) agent derived from a Pacific Ocean sponge. Another project involved the development of non-toxic coatings for ships that prevent the build-up of fouling organisms, such as barnacles and zebra mussels.

Advances in marine biotechnology have made great improvements for the aquaculture industry, which serves as an important food source and export commodity in many poorer countries. Aquaculture is gaining importance in this country as well, as consumer demand for fish and shellfish becomes greater than can be met by traditional commercial fishing. For example, marine biotechnology has led to the development of a triploid oyster whose meat remains firm and sweet throughout the entire spawning season (May to August). This development has extended the harvesting and marketing season of the oyster, increasing its economic value.

Marine researchers are also experimenting with the use of ultrasound for administering drugs to diseased populations of farm-raised fish. When pens of fish are exposed to ultrasound (high frequency sound that cannot be heard by humans), the outer layers of their tissues such as skin and gills become more permeable. This makes the fish more receptive to a vaccine or antibiotic drug that is released into the water. This method represents a great improvement over injections, which involves handling each fish and can place them under stress.

Other popular areas within the

You Say "Marine Biology," I say "Biological Oceanography"...

Throughout this guide to marine careers and in many other publications about marine science and oceanography, you will come across the terms "marine biology" and "biological oceanography," often used interchangeably.

One distinction that has been made between the fields of marine biology and biological oceanography is that marine biologists study the plants and animals of our estuaries, coasts, and oceans, ranging from whales to microscopic algae and bacteria, and biological oceanographers study marine organisms and their biological processes *within the context of their natural environment*. In that sense, marine biology could be considered a subset of biological oceanography.

Another way of looking at it, says Larry Harris, a professor of zoology at the University of New Hampshire, is "marine biology is biology with salt added. You can do many kinds of biology and be a marine biologist as long as you are working with marine organisms or marine systems." While it is true that some marine biologists have little or no training in oceanography — especially at the undergraduate level — others have a great deal of oceanography background.

In any case, don't let the terminology get you confused! Instead, read the profiles featured here to meet people working in a career area, specialty, or field that interests you, and use their experiences and background as a guide.

Remember, there are many paths available to you and many choices you can make to get to where you want to be. In fact, Professor Harris says, "the longer I teach students in marine biology, the more amazed I become at the diversity of occupations that are available to students in marine biology."

field of marine biology are environmental biology and toxicology. Both of these areas have direct applications and implications for our society, such as water quality research or studies on contaminants or pollutants in the coastal or marine environment. Laws, regulations, and cleanup measures designed to protect the environment will ensure that marine and environmental biologists and consultants continue to play an important role in our society.

Summary

Specializing in one aspect of marine biology or biological oceanography is common, but working with specialists in many other fields to reach a balanced solution — one that considers all sides of an issue — will yield the most beneficial answers to modern society's questions.

David Caron, a biological oceanographer at the Woods Hole Oceanographic Institution, summed it up well when he wrote:

"... it is clear how important biological oceanography is in addressing the future of our planet. Researchers in many different aspects of biological oceanography share a common goal: We strive to understand how the ocean functions, define the limits of its abilities to absorb our activities, and assure that we do not exceed those limits. Ultimately, this knowledge is critical to the continued health of the ocean, planet, and our own future."
Oceanus, (35:3), 1992

Steve Jury • *marine biologist*

B.A., zoology, Univ. of New Hampshire
M.S., zoology, Univ. of Massachusetts, Amherst

current job: I work for the Strategic Environmental Assessments Division of the National Oceanic and Atmospheric Administration, which is located in Silver Spring, Md. We are creating a national database of fishery information (basic biology, fishery and catch statistics, etc.) from all available sources. This database will be used in the management, conservation, and study of our estuarine and coastal areas.

key factor: My desire to be intellectually and physically stimulated by my work and still get paid for it. Having the opportunity to be creative and innovative was also important.

like most: Being involved in the creation of knowledge, continually learning, and having the freedom and opportunity to explore new ideas.

like least: Paperwork and the politics of doing science.

relax: Mountain biking, water sports, reading.

heroes/heroines: Anyone who explores the limits of his or her mind and body.

advice: Even though it's difficult to decide what you want to do, try to start thinking about a direction as soon as possible. At the same time, get a good foundation of study in all subjects because the knowledge and skills that you learn early on tend to stay with you.

career opportunities: I think that jobs in marine biology are being created and lost at about the same rate. Nevertheless, opportunities in certain specializations appear to be increasing with the growing public awareness of the environment.

10 years: I hope I will have my Ph.D. and be doing field research and teaching.

Sonya Wood • *environmental educator*

B.S., marine biology/marine geology/physics, Auburn Univ.
B.S., secondary science education, Auburn Univ.
M.S., environmental education/natural resources, Univ. of Wisconsin, Stevens Point

current job: I am a marine extension agent for Florida Sea Grant. My office is in Pensacola, but I work throughout Escambia and Santa Rosa counties. I'm a marine biologist with a twist. I do a little research and a lot of education. Working with both adults and children, I coordinate a variety of marine-related programs. This includes organizing clean-ups, marine mammal rescues, sea turtle monitoring efforts, manatee dive trips, 4-H programs, estuary canoe trips, and a range of other such activities. I also distribute a quarterly newsletter called ***Turning the Tide*** and other Sea Grant and Cooperative Extension publications.

key factor: I wanted to work in the marine environment. I grew up on the coast of the Gulf of Mexico and I wanted to live and work here. That was far more important to me than how much I would make. I worked in marine mammal research and taught marine biology in high school before finding my current job, which is perfect for me. I bring the research to a wide audience in a way that they can understand it and use it.

like most: The tremendous flexibility and variety. The opportunity to be creative. I get paid to do what I love to do and live in Paradise!

like least: This is definitely not a nine-to-five job. I work a lot of nights and weekends because that is when the audiences are available. There are a lot of 60-hour weeks.

relax: Bike riding, racquetball, windsurfing, waterskiing. I do a lot of photography, both under water and above. I work with Habitat for Humanity, building houses and putting in drinking water systems. I walk my dogs on the beach.

heroes/heroines: Edward Abbey, Bev Doolittle, Jacques Cousteau, Sylvia Earle, Charles and Ann Morrow Lindbergh, Richard Wilke, Lois Armstrong.

advice: Get lots of field experience (on weekends, in the summer, as a volunteer if necessary) to make sure this is what you enjoy and to develop your skills. Also, get experience in public speaking, writing, computers, graphics, photography, lab work, scuba or skin diving, and the identification of marine mammals, fish, corals, shells, marine invertebrates, aquatic plants, and shorebirds.

career opportunities: The number of positions like mine with federal and state agencies has decreased slightly. I think the future will see increasing competition for positions in environmental fields.

10 years: I will be working for Sea Grant in some coastal state as an agent or specialist. I would like to specialize in communications, marine debris, or marine mammals. I may return to school for a Ph.D. I would like to take a sabbatical to work for a year in Australia or on the Caribbean.

Percy M. Washington Jr. • *fishery biologist*

B.S., fisheries biology, Univ. of Washington
M.S. and Ph.D., fisheries science, Univ. of Washington

current job: I am the principal shareholder, senior aquatic ecologist, and president of Gaia Northwest, Inc., an aquatic ecology/civil engineering consulting business that employs scientists, engineers, and technicians. I study and consult on various problems associated with marine and freshwater fishes. We are located in Seattle, Wash., but work in California, Oregon, Idaho, and Alaska as well. I also teach a fishery course at Western Washington University.

key factor: I tried several majors before I hit on fisheries. Fisheries training led to jobs in Alaska and Washington. Taking advantage of opportunities provided more opportunities and so on.

like most: My career provides an opportunity for me to grow and learn in everything I do. I get to learn, teach, travel, publish my ideas, and influence the determination of the best ways to ensure a quality environmental legacy for future generations.

like least: I'm over 50 and may only have another 20 to 40 years of productive work life.

relax: I most enjoy fishing. I enjoy the preparation, which includes the manufacture of rods and lures, the maintenance of gear, and learning about species. I enjoy all types of fishing, including fly-fishing for trout and salmon throughout the West, British Columbia, and Alaska; billfish fishing in Mexico; and halibut fishing in Alaska. I also enjoy writing essays for publication.

heroes/heroines: My parents, grandparents, teachers, coaches, and friends, who cared enough to spend time with me. All were important in providing me with a sense of self importance, dignity, moral and spiritual values, and direction. My youngest son, who has a learning disability and the intense desire to succeed in spite of it, has taught me perseverance.

advice: Take every opportunity to develop skills in reading, writing, and speaking. Understand that your inability to perform well in math and science may be a reflection of the teaching and exposure you have received, not your ability or intelligence; work to improve your skills. Remember that learning, knowledge, and wisdom (in the use of this information) are lifelong commitments, no matter what you decide to do.

career opportunities: As the awareness of the impacts of human population growth continues to grow, along with an understanding of the need to mitigate those impacts, the need for the services that I offer will increase. There is always a need for intelligent, well-educated people to fill this type of need in a growth market.

10 years: I intend to be offering the same types of consulting services that I am currently, as well or better.

Ann Bull • *marine biologist*

A.S., math and chemistry, St. Petersburg Junior College
B.S., marine biology, Texas A&M Univ. (candidate)

current job: I am the operations coordinator for the Texas Marine Mammal Stranding Network in Galveston, Texas. My office responds to all marine mammals that strand (dead or alive) along the coast.

key factor: I have always been fascinated by marine mammals, dolphins and whales particularly. This job gives me the opportunity to work with these magnificent animals and to educate people about them.

like most: When we are able to rehabilitate and release a marine mammal, while at the same time sharing the experience with newcomers and veterans alike.

like least: The painful times when we suffer the loss of an animal.

relax: I enjoy scuba diving, swimming, sailing, and reading. I love to be out on the water and see dolphins enjoying themselves.

heroes/heroines: They are those scientists and volunteers whom I have had the opportunity to work with who are not only dedicated and hard working but who give their hearts and souls to assuring the survival of a marine mammal.

advice: The hours are long and the work is hard, but the results are the most gratifying you will ever experience in your lifetime. My advice would be to never give up and you can achieve your goals.

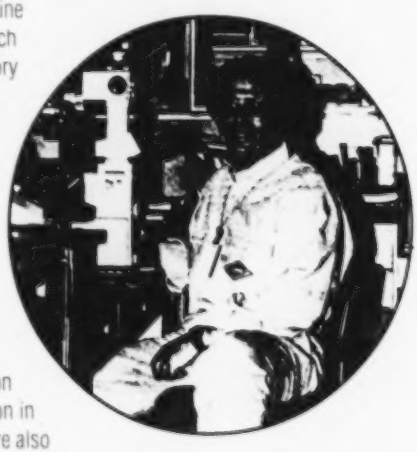
career opportunities: Presently they are decreasing due to government budget cuts. Hopefully, the importance of research and agencies like the stranding network will be realized before too long.

10 years: I am sure 10 years from now I will still be working with marine mammals. I have truly found my place in life.

David Lapota • *marine biologist*

B.S., zoology, San Diego State Univ.
M.A., geography, San Diego State Univ.
Ph.D., biology, Univ. of California, Santa Barbara

current job: I am a marine biologist at a Navy research and development laboratory in San Diego, Calif. I am the principal investigator for bioluminescence projects. One of my responsibilities is to analyze plankton samples we have collected from the ocean. Through this research, we hope to understand the distribution of bioluminescent plankton in the world's oceans. We are also developing a biological test that uses various organisms to detect toxicity in the marine environment.



key factor: I have always been fascinated with life at the seashore. However, while I enjoyed taking biology and physiology classes in high school, I wasn't much of a student in other areas. Then I took an invertebrate zoology class from Harvey Kirk at Santa Monica College. The course work was fascinating and the enthusiasm this teacher instilled in me really turned me around. I knew at that point that I wanted a career in marine biology and I also realized I needed to apply myself in school.

like most: I enjoy the diversity of the projects that we undertake. They vary from biological oceanography, which involves working on board oceanographic research vessels in various locations such as the Arctic or the Arabian sea, to studying the effects pollutants have on marine larvae in the laboratory. My research has allowed me to travel extensively and I have had the opportunity to meet and work with scientists from around the world. The challenge of operating in the field to try and understand biological processes can be quite rewarding, scientifically and personally.

like least: Report writing.

relax: I enjoy photography and relaxing on the beach watching the waves roll in. I also enjoy traveling.

heroes/heroines: Harvey Kirk, who gave me the motivation and desire to achieve my goal of becoming a marine biologist. My parents, who always encouraged me to strive to do my best.

advice: Study hard in school. Keep your interests in perspective with what you want to do in later years. Always try your best, even in the courses that don't seem too relevant. You'll be surprised by what will turn out to be useful later on. Motivation and perseverance are also very important. Unfortunately, these attributes cannot be taught, they must come from inside the person. If you find some avenue of study that intrigues you, go with it and give it everything you've got.

I would also encourage you to obtain work experience in your field of interest. This is very important as it allows you to discover if this type of work is really what you want to do.

career opportunities: As more attention is given to the environment, I believe there will be more opportunities for assessing and monitoring biological populations in bays, estuaries, coastal areas, and offshore waters. Special attention will be given to contaminated marine sediments and their impact on surrounding plants and animals. Toxicological testing will be required by all agencies or individuals planning on discharging effluents into the marine environment. Therefore, more biologists will be needed to do the testing. Apart from these environmental opportunities, I believe marine biologists will be needed in a wide array of specializations.

10 years: I hope I will still be able to go to sea and conduct basic research in oceanic bioluminescence. I would also like to pursue my interests in aquaculture at some later time.

Gladys B. Reese • *fishery biologist*

B.S., liberal arts & science, Southern Univ.

current job: I am a fishery biologist with NOAA's National Marine Fisheries Service in Pascagoula, Miss. I serve as a principal researcher or as a member of a research team investigating critical problems in fisheries resource management and recommending solutions.

key factor: A genuine interest in understanding how things work and a love of learning and of science have guided my career.

like most: The opportunity to work independently, the opportunity for continuous learning, the joy of problem solving and discovery, and the

opportunity and the facility to promote the conservation of our nation's living marine resources through scientific endeavor.

like least: There are things that annoy me from time to time, but most of them are overcome with a positive attitude. I enjoy my chosen career.

relax: Work! I enjoy what I do tremendously. I enjoy the challenges of problem solving and learning. I am happiest and most relaxed when working. Also, gardening, reading, and solving cross-word puzzles are relaxing pastimes.

heroes/heroines: My mother and grandmother are my heroines. They set positive examples for me early in life. They instilled ideals and values in me, and taught me that anything I could dream of and work hard for I could achieve. They taught me to believe in myself and gave me the love, support, and guidance I needed to achieve my goals.

advice: Learn everything you can about your chosen field. Get a broad perspective on all areas of the marine-related sciences. Visit career fairs and talk to people who work in your field of interest. Set goals, be dedicated to your ideals, adopt good study habits, and maintain good grades. Take as many math, biology, chemistry, physics, and computer classes as possible. Gain experience and learn more about marine science by becoming a student volunteer with aquaria, research facilities, water quality monitoring projects, beach cleanups, etc. Get information about colleges that offer major studies in marine science fields and start early to look into ways to help finance your education. Believe in yourself.

career opportunities: The field of marine fisheries biology is limited in terms of employment. However, the broader area of marine science is closely involved with the environment. As such, you can expect an increase in demand for well-trained people. Especially those who are trained to deal with environmental problems.

10 years: I will be retired, and entering a second career in business or the law.

Stephen Truchon • *marine ecologist*

B.A., biology, Plymouth State College
M.S., zoology, Univ. of New Hampshire

current job: I am a marine ecologist/biostatistician with ENSR Environmental Consulting and Engineering of Acton, Mass. Most of my work involves studying habitats and assessing marine and estuarine ecosystems. Generally, I spend 75% of my time in the office and 25% in the field. The office work includes analyzing data and writing reports. The field work includes sampling the water, sediments, and plant and animal life of both contaminated and uncontaminated sites. I have sampled marine and estuarine environments all along the East Coast and in Puerto Rico.

key factor: I have always loved the ocean. As a teenager I spent as much time as I could near it, either working as a lifeguard or surfing. When I was 17, I took a scuba diving course that exposed me to the ocean and the interesting life in it. I wanted to know more about what I was seeing, so when I entered college I took as many marine biology courses as possible.

like most: I enjoy the challenge of designing and conducting environmental sampling programs and then analyzing the results using statistical methods. Essentially, it's my involvement in a project from start to finish that I enjoy the most.

like least: Most of the time the work is very stressful, with tight deadlines and slim budgets. As a result of these constraints, I am often forced to draw my conclusions and make my report before I've had enough time to really study the subject and analyze the data. This is frustrating.

relax: I like to run on the beach, scuba dive, ride motorcycles, read a good science fiction book or the Sunday paper, and play golf.

heroes/heroines: Richard Truchon (my father), Richard Fralick (a Plymouth State College professor), Clint Eastwood, Stephen J. Gould, and Dave Shea. Dave is a coworker of mine who makes his family a priority and is committed to the happiness and interests of his children. In a lot of ways, he reminds me of my father when I was growing up.

advice: Try to get some experience in the marine sciences by working as a library assistant, laboratory assistant, or teaching assistant. Ask your science teachers or guidance counselors if they can help you find such an opportunity at local colleges, government agencies, or private firms. You might be able to find a job sorting biological samples, prepping labs, conducting computer searches, entering data, or even assisting in fieldwork. Whatever you can do now will only help you when you apply to college.

Once at college, get to know your professors and their interests. Apply for work-study positions with these people. You'll be amazed at how quickly your experience and qualifications will develop.

career opportunities: In environmental consulting, opportunities for marine scientists are growing, particularly for those with an M.S. or Ph.D. Marine scientists with technical abilities in photoimagery analysis, biostatistics, sediment toxicology, and other such areas are frequently sought after and tend to assume more of a role in the decision-making process of research projects. Also, individuals who can serve in more than one capacity — as a manager, a technical specialist, and a field crew member, for instance — are more marketable than those who cannot.

The condition of the environment also provides for opportunities in the marine science field. We as a people face increasing problems with

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industrial pollution from the past, the present, and the future. Solving these problems will require more scientists who are knowledgeable about marine and freshwater ecosystems.

10 years: I will probably still be in the environmental business, either as a senior technical specialist for an environmental consulting firm or as a biologist for a government agency. As I get closer to retirement, I would like to teach biology to high school or college students.

Mary C. Fabrizio • *fishery biologist*

B.S., biological sciences, Fordham Univ.
Ph.D., biological oceanography, Univ. of Rhode Island

current job: I work for the Great Lakes Center of the National Biological Survey, a component of the U.S. Department of the Interior. Our center, which is located in Ann Arbor, Mich., includes research biologists and chemists who work on issues related to fish populations and contaminants in the Great Lakes. I study changes in abundance of important fish species, such as lake trout, the alewife, bloater chub, and rainbow smelt. In this work, I rely on data collected by a number of other scientists, both on the lakes and in the lab, and I use sophisticated computer systems to run graphics programs and statistical models.

key factor: Two events helped me select my current profession. At a very young age, I developed a fascination for marine organisms — in particular, plankton. My parents fostered my interest in this area by giving me books about the sea. I was hooked! Then, during my senior year in college, I worked with a fishery biologist at a field station in upstate New York doing research for my senior thesis. From that experience, I discovered that fisheries were just as challenging and every bit as fascinating as other fields of marine biology.

like most: I like the challenge. My career allows me to bridge the gap between basic fishery science (How long does this species live? Why does it migrate from one area to another?) and resource management (How can we prevent this species from becoming extinct? How can we harvest this resource without affecting its persistence?). The challenge is in identifying and using the basic tools to answer the questions that will help resource managers make decisions about fishery resources.

like least: There are few women in this field, and even fewer with Ph.D.s. Some of our colleagues find it difficult to interact with professional women in a meaningful manner. The result is that women are frustrated by having to "prove themselves" continually. However, things are beginning to improve as more and more professionals (men and women) are making efforts to include women on committees, projects, editorial boards, and the governing bodies of professional societies.

relax: I like to read books about nature or travel. I also like to garden and prepare gourmet foods. When I have more time, I like to explore creative painting techniques. My husband and I like to hike and sail.

heroes/heroines: To me a hero is someone who has the courage to stand by her (or his) convictions. Many famous people come to mind, but I like to find my heroes among my friends and family — people with whom I interact and from whom I gather inspiration.

advice: Think about why you are interested in this field and be honest about this interest. A scientific career is a serious undertaking, requiring dedication and determination.

Take every opportunity to explore your interests further by visiting a museum of natural history, by taking special classes in a related subject, by selecting marine science or fishery biology as the topic of special reports or other classroom assignments, and by visiting a federal or state laboratory that conducts research in this area (for example, the National Marine Fisheries Service, the National Biological Survey, or the U.S. Fish & Wildlife Service). For young girls, if you can find a local chapter of the American Association of University Women or the Association for Women in Science, get in touch with the mentorship program and ask to be assigned a mentor from your field of interest.

Take as many math courses as you can, and continue to do so in college. Many jobs in biology are now filled by candidates with a strong background in mathematics or statistics. Of course, you should also be able to work with computers.

career opportunities: Career opportunities in fisheries science appear to be decreasing. The few who do find jobs are those with strong skills in fisheries and in math and computer science. I believe the opportunities are decreasing because of economics; state and federal agencies are not opening new positions because of limited funds. Academic positions are even harder to find because most academic institutions appear to be reducing the size of the faculty in the natural sciences. Private agencies (such as consultants and contractors) appear to be hiring environmental specialists, but I believe most of the new jobs are related to environmental regulations and focus on environmental cleanup.

10 years: I'd like to be using my expertise to direct research at a large laboratory and assist in defining goals for a staff of research scientists. I'd like to assist in identifying the needs of resource managers and the research projects necessary to better manage our fishery resources.

Stephen C. Jewett • *marine biologist*

B.S., biology, John Brown Univ.
M.S., biology, Univ. of Alaska, Fairbanks
Ph.D., fisheries, Univ. of Alaska, Fairbanks (candidate)

current job: I am a research associate and the scientific diving officer at the Institute of Marine Science of the University of Alaska, Fairbanks. The research associate position entails initiating, coordinating, and working on research projects in the area of marine biology and fisheries throughout Alaska and the Pacific Northwest.

Over the past six years I have been involved in examining the effects of the Exxon Valdez oil spill on invertebrates and fishes in the nearshore waters of Prince William Sound, determining what is limiting the recovery of sea otters and other vertebrates impacted by the oil spill, examining the effects of an offshore gold mining operation on red king crab, examing the welfare of pink salmon from a hatchery adjacent to an oil terminal, and examining the effects of a pulp mill on marine life.

As diving officer, I oversee all scientific diving operations conducted by students, staff, and faculty.

key factor: While growing up on the coast of Maine, I spent much of my time in and on the water. It was this exposure, coupled with an inspirational high school science teacher, that planted the seed for me to pursue a career in marine biology.

like most: The field activities associated with sampling, making observations, and collecting data interest me the most. I seldom have a dull project in a dull location. The frequent use of scuba diving and two-person submarines are also highlights.

like least: The tedious compilation of frequent reports.

relax: Scuba diving, swimming, fishing, hunting, running, and coaching baseball.

heroes/heroines: There are two people who were most inspirational to me in pursuing my career, my high school science teacher and my undergraduate advisor. Both were articulate and enthusiastic in revealing some of the wonders of God's creation and challenging me to discover more.

advice: Take all of the math, science, and computer courses you can. Get some hands-on experience by doing projects for science fairs or by attending summer camps that focus on science. Visit aquaria and museums. Develop good swimming and scuba diving skills.

career opportunities: I believe that job opportunities in the field of marine biology and other marine sciences are expanding, primarily because of the increasing awareness of worldwide pollution, the potential of the oceans to help alleviate increasing world food shortages, and the role oceans play in global climate. In addition, the aquatic environment provides the setting for a multitude of uses, such as boating, fishing, farming, mining, and transportation.

10 years: I hope to be doing many of the same things I'm doing today. So long as I remain healthy and my appetite stays strong for trying to unlock some of the secrets of the ocean world I will continue to pursue my love for marine biology. I would like to work temporarily in other oceans of the world, such as in Antarctica and the tropics.

Deborah A. Bouchard • *aquaculture microbiologist*

B.S., microbiology, Univ. of Maine

current job: I manage the aquaculture diagnostics and bioassay laboratory at Northeast Laboratory, an environmental testing lab in Winslow, Maine. The aquaculture diagnostics workload consists primarily of performing fish health inspection and certification procedures on cultured species for aquaculture companies located throughout New England and the Maritime Provinces. Fish health inspection work is performed in order to establish the health status of cultured aquatic species to avoid the spread of disease to wild fish resources. I am a certified fish health inspector for both the U.S. and Canada.

The bioassay workload consists primarily of performing toxicity tests for public and private facilities discharging wastewater into surface waters, such as rivers and streams. These toxicity tests measure the toxic effects of pollutants on representative species of aquatic organisms found in surface waters.

key factor: The key factors in my career decision came from my experiences as a student and a student worker in the microbiology department at the University of Maine. Many of the professors I took classes with and worked for were doing research with fish diseases. My first professional position was doing fish disease research in the microbiology department.

like most: I work both in an outdoor environment and in the laboratory. I enjoy working at the aquaculture marine sites and hatchery locations. It is a pleasure interacting with the fish farmers in a hands-on situation. I also enjoy performing the technical microbiology tests at the laboratory.

like least: At present, my position involves somewhat of an unpredictable work schedule controlled by factors such as weather and fish life cycles. These factors can result in 15-hour work days with no rest the following days because of testing procedures.

relax: I have many hobbies that help me to relax. I enjoy dancing, photography, weight lifting, walking, and reading novels.

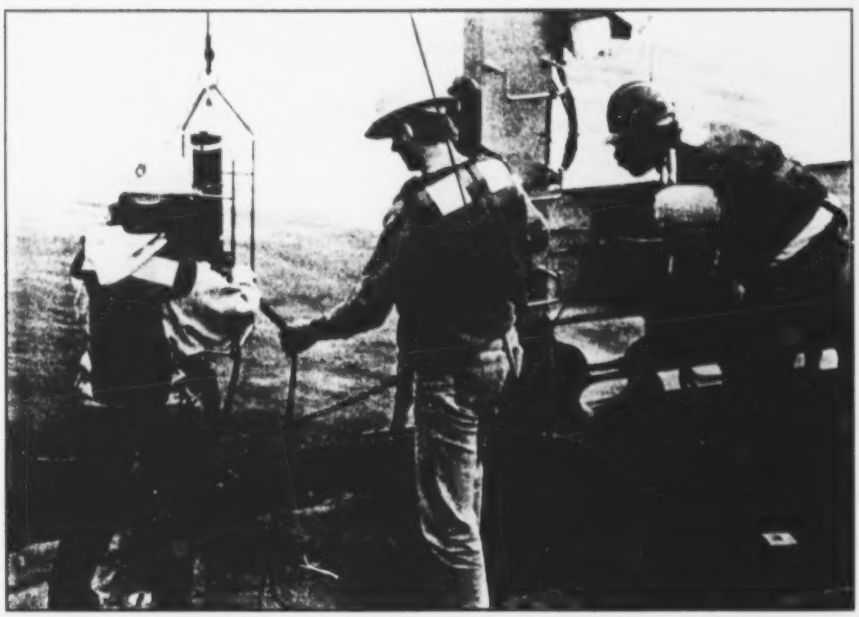
heroes/heroines: I really admire people who stand up for what they believe in and live by their convictions even in the face of obstacles.

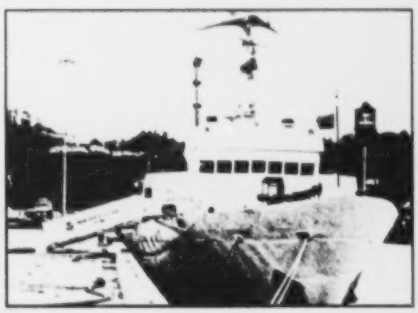
advice: There are many courses of study a student can choose from to pursue a career in marine sciences. Choose the course of study that interests you the most. Enjoy your college years. Leave all your options open and volunteer for every source of work experience possible.

career opportunities: They are increasing in the area of fish health. Aquaculture is a new and expanding field. As the type and number of cultured organisms increases so will the demand for aquaculture support and health specialists.

10 years: It's difficult to determine what I will be doing in 10 years. My career has changed and progressed. I will leave all my options open and I hope to continue to grow and learn as the years pass.

Oceanography





Oceanographers from the University of Washington and the National Oceanic and Atmospheric Administration are studying the influence that water from the Columbia River has on water salinity in the northern Pacific. Here, a research team — Remus Gladden, Andrew Newell, and Deanne Niemer, left to right — takes a water sample from the deck of the research vessel McArthur.

A chapter that attempts to combine three major disciplines of oceanography — marine geology and geophysics, physical oceanography, and marine chemistry and geochemistry — should be prefaced with the explanation that the subfields of oceanography are closely related. Oceanographers and others involved in these disciplines often work together to unravel the mysteries and unknowns of ocean science. In many government-sponsored research efforts, preference is given to research projects that integrate the separate disciplines of oceanography and incorporate important principles from each to better understand a system, phenomena, event, or process.

As a growing global population stresses the ability of our society to produce food, water, and shelter, we will continue to look to the oceans to sustain our basic needs. Advances in technology, combined with demand, will improve our ability to derive food, drinking water, energy sources, waste disposal, and transportation from the ocean. It will be up to this and future generations to build upon our existing knowledge of the ocean and its potential to help meet the needs of the world and its inhabitants.

In reading about each of these subfields, keep in mind that some of the most important oceanographic discoveries have been made as a result of an integrated, multidisciplinary approach, often involving geologists, chemists, biologists, physical oceanographers, and engineers.

The 1977 discovery of active hydrothermal vent communities illustrates the benefits of this multidisciplinary approach. At these active hydrothermal vent sites, oceanographers observed thriving populations of hundreds of "new" species, including tube worms and giant clams. "Black smoker" chimneys also were observed, venting hot, metal-rich fluid that generates from within the Earth's crust and can reach temperatures as high as 350°C. Just outside these chimney-like structures, the water is much cooler — about 2°C — and has a higher pH. When these

fluids meet, a reaction takes place and forms black "smoke."

Although the vent sites are located at the bottom of the ocean floor where there is no light, and therefore no photosynthesis to provide plant food for other organisms, life is plentiful. Scientists soon discovered that the chemistry of the water at these vent sites provides energy for bacteria to grow by chemosynthesis, in much the same way sunlight provides energy for plants to grow by photosynthesis. After a certain amount of time, scientists believe these vent areas become inactive; when this occurs, the inhabitants of the community die off.

Just as many advances in the marine sciences have been made by multidisciplinary teams of researchers, so too have important discoveries been made by scientists working on a focused topic.

Marine Geology and Geophysics

As many interesting geological features as there are on land, nearly as many exist within, under, and at the boundaries of the oceans. Mountains, valleys, volcanoes, islands, plains, canyons — all exist in similar form in the marine realm. In fact, Earth's largest continuous mountain chain is the Mid-Ocean Ridge, stretching for over 40,000 miles and rising above the surface of the water in a few places, such as Iceland. The Mariana Trench, located in the central Pacific Ocean, is deeper, by about a mile, than the highest point of Mount Everest. Active deep-sea volcanoes, located along mid-ocean ridges, supply rich mineral deposits and new rock formations on the seafloor. Marine geologists locate the underwater volcanoes by using sonar and acoustic techniques that bounce sound waves off the rock formations. They also use remote sensing technology to map the ridges and valleys. It has been written that the ocean bottoms are the most active places on Earth, from a geological perspective.

Conditions at many of these sites make it difficult for marine geologists to visit and study. Without the technological advances of only a few decades ago — piloted submersibles, remotely operated vehicles (ROVs), and programmable acoustic instruments attached to ships — oceanographers could only speculate about the very existence of such features, much less develop the accurate maps and detailed, 3-D computer models of the seafloor that exist today.

Geological oceanographers study the seafloor — its formations, composition, and history. They examine sediments, including physical characteristics such as size, shape, color, and weight; chemical characteristics, such as composition and how sediments interact with the environment; and other factors, including sediment age, origin, distribution, and transport. By combining their knowledge of marine chemistry and physical oceanography, marine geologists help piece together information about how the Earth formed and how the movement of plates and continents results in events such as volcanoes and earthquakes. Also, marine geologists work with biologists and chemical oceanographers to learn more about historical climate records and animal and plant life by examining sediment and rock cores for fossils and analyzing sediment composition using radiocarbon dating and other methods.

Some of the major areas of specialization within the field of geological oceanography are described below:

Seismology

Marine seismologists map the Earth's interior structure by looking at changes in the way sound travels through the planet's various layers. These sound patterns appear as "waves." Seismic energy travels as an elastic wave, meaning that it can be reflected from the seafloor ("reflection") or it can penetrate through the seafloor and the layers within the Earth's interior and be bent as it travels ("refraction"). An important tool used by marine seismologists to "read" patterns of sound waves is the seismogram. You have probably seen examples of seismograms, which look like a series of squiggly vertical lines, from measurements of earthquake patterns. The instrument that records these measurements is called a seismometer. Though it's hard to imagine, there are thousands of microearthquakes beneath the ocean floor each day! Although marine seismology has told us many things about the Earth's surface and interior over the last couple of decades, more work is needed to answer important questions such as: What do mid-ocean ridges, fracture zones, and continental margins look like in 3-D, and how did they form? What is the Earth's deep interior really like? What are structures in the upper mantle of the Earth like, and what is their role in plate interactions?

Ocean Drilling

The international Ocean Drilling Program (ODP), successor to the Deep Sea Drilling Project (DSDP) begun in 1968, is a partnership of scientists and governments created to explore the Earth's origin and evolution beneath the seafloor. Aboard the drill ship ***JOIDES Resolution***, researchers from around the world gather samples of sediment and rock from below the ocean floor. (The "JOIDES" part of the ship's name stands for Joint Oceanographic Institutions for Deep Earth Sampling.)

Important discoveries made by the ODP include a new understanding of the causes and history of ice ages, the evolution of the continental margins, Earth's tectonic processes, marine sedimentation, and the origin and evolution of oceanic crust. Investigators involved in the ODP program may specialize in sedimentology (the study of matter that settles to the bottom of the sea), paleontology (the study of fossil plants and animals and of the rock formations in which these fossils are found), petrology (the study of the origin, occurrence, structure, and composition of rocks), geochemistry, geophysics, and paleomagnetics.

As one might expect, these discoveries have led to new research questions. Drilling and sampling ocean sediment and crust will remain important to the field of oceanography. ODP officials predict that the program will assist and become more integrated with other earth science

programs, such as the international program of mid-ocean Ridge Interdisciplinary Global Experiments (RIDGE), the Ocean Seismic Network, and the work of hydrologists and geochemists worldwide. Clearly, ocean drilling will continue to yield important clues about earthquakes, global change, sea-level rise, climate, and ocean history.

Ocean Mining, Oil and Gas Exploration

Ocean manganese nodules, small, dark, and round-shaped nodules that contain manganese, nickel, copper, cobalt, and other minerals, are found along the floor of the Atlantic and Pacific oceans. The nodules were first discovered on the famous oceanographic ***Challenger*** expedition of the 1870s. Steel production requires millions of tons of manganese annually. Though ocean mining for manganese nodules has generated a great deal of interest, several factors have served as obstacles, including the difficult ocean terrain, the high cost of ocean mining, and political and international difficulties relating to the legality of ocean mining.

Similar problems associated with oil and gas exploration have caused international and national debate. While no one knows the exact extent of the oil and gas deposits in the ocean, oceanographers have made important discoveries about these potential reserves. The cost of exploring these sites is high. And, even if oil or gas reserves are found, recovering the resources is not always pursued due to the high cost of developing the site or other reasons. Partnerships between scientists and industry are important in the area of oil and gas exploration; oil companies constantly seek new reserves, while science makes it possible for companies to locate, analyze, and reach the resource. Current production takes place in the oceanic areas of continental margins, such as the Gulf of Mexico and the North Sea.

Coastal Geology

An increasingly important area of marine geology is coastal geology. Throughout history, the human population has shown a tendency to settle along the world's 273,000 miles of coastline. The effects of humans inhabiting our shores and coastlines have become increasingly apparent. Coastal pollution and waste disposal are creating problems and costing government and industry billions of dollars in research and remediation efforts. Although the percentage of people living on the coast is expected to remain fairly constant over the next few decades, total numbers are expected to increase as population continues to increase.

In addition to human effects on our shores, natural coastal processes such as rising sea level, erosion and sediment transport, and storm-related events such as flooding, severe erosion, and storm overwash make our coastal areas dynamic environments. Often, humans react by attempting to protect structures situated along the coast, including homes, businesses, and roads, even when these structures are located on land forms, such as barrier beaches, that are "temporary" in a geologic sense of time. To protect these structures, coastal engineers have developed and constructed seawalls, jetties, groins, and bridges. More recently, natural or "soft solutions" such as constructed wetlands and salt marshes have been developed to slow the effects of coastal processes. Coastal geologists and coastal engineers, working with oceanographers from each of the disciplines, will be instrumental in forming policy and management options to minimize the conflicts between coastal development and natural processes.

Physical Oceanography

Most oceanographers try to think of the world's oceans as one giant system, collectively known as the global ocean. But before space travel and the invention of satellites, it was very hard to actually observe the oceans on such a large scale. Pictures of the global ocean from space have given oceanographers important information about its currents, temperatures, and other properties. Satellites collect information around the clock and feed it back to earth — and individual laboratories and classrooms — in real time. This innovation has revolutionized oceanography and given researchers important information about weather and climate, circulation, and environmental problems, such as global warming, global circulation, the world's fisheries decline, and red tide.

Perhaps more than any other group of oceanographers, physical oceanographers have benefited from satellite technology. Because they study the movement of the oceans and the forces that cause motion — such as winds, waves, and tides — they must look at the ocean from a "big picture" perspective. Shipboard measurements and the development of instruments such as computer programmable buoys that can be left at sea for long periods of time were huge advances for the field of physical oceanography and continue to be important tools, but satellites offer perspectives that early oceanographers may never have dreamed of. Imagine the discoveries Benjamin Franklin, the first person to plot the course of the Gulf Stream, could have made if he'd had access to satellite data!

Physical oceanographers study the interaction between the ocean and its boundaries — land, seafloor, and atmosphere — and the relationship between the sea, weather, and climate. Questions about how the oceans work in a physical sense include investigations into water qualities such as temperature, salinity, density, and influential factors such as wind speed, air temperature, tides, and interaction with nearby land and underwater formations.

Physical oceanographers seek to understand why, where, and how water moves — on all space and time scales — and the consequences of these movements for a vast range of purposes. Some physical oceanographers are theoreticians and use computer models to answer questions and form hypotheses about oceanographic processes. Others use observations and, increasingly, satellite observations. Understanding the

global ocean requires a close partnership between theory, observations, and experiments.

Often, physical oceanographers work with their biological, chemical, and geological colleagues to address a particular phenomenon or unknown. Understanding the way the ocean works, physically, supplies oceanographers in the biological, geological, chemical, or engineering disciplines with important details they need to answer questions. The physical properties of the ocean are intimately linked to the biology and chemistry of the ocean, and vice-versa.

For example, in one important study, satellite data revealing coastal ocean currents, circulation, and temperature along the northeastern U.S. may provide the missing link for biological oceanographers investigating mysterious outbreaks of red tide from Maine to Cape Cod, Mass. Satellite pictures suggest that the toxic algae that cause red tide are being transported by a buoyant coastal current originating in the rivers of southern Maine and extending hundreds of miles southward. When the toxic algae are eaten by shellfish, they pose a serious human health risk; if undetected, humans who eat the shellfish can become seriously ill or even die. Biologists hope to continue their work with physical oceanographers so that, one day, they may be able to predict red tide events.

Chemical Oceanography

The ocean has been referred to as a "chemical soup" because it contains many chemical compounds, elements, gases, minerals, and organic and particulate matter. While water is the most plentiful ingredient, salts are among the most important. Amazingly, despite the major changes that have taken place on Earth since its beginning — continental collisions, land formations, glaciation — the basic composition of seawater has remained relatively constant for millions of years.

Chemical oceanographers, also called marine chemists, marine geochemists, or even marine biogeochemists, study the formation of seawater and seafloor sediments, relationships between chemical compounds (both organic and inorganic), how chemical inputs to the ocean (including pollution) affect it, and how the chemistry of the ocean affects or is affected by biological, geological, and physical factors. As with the other disciplines of oceanography, chemical oceanographers rely on and interact with researchers from the other disciplines.

One important aspect of chemical oceanography is the study of pollutants. This work may lead chemical oceanographers to the deep ocean, coastal bays and estuaries, or inland rivers, streams, and lakes. Sources of pollutants range from the obvious (sewage, oil or fuels, ocean dumping) to more subtle sources that can be hard to detect or trace (agricultural or lawn runoff containing chemical fertilizers, leaking septic systems, road runoff, or storm drain overflows). Chemical oceanographers study the impact of such pollutants by examining how they interact with seawater, marine life, and sediments. Chemicals and pollutants can react very differently depending on environmental conditions such as salinity, wind, rainfall, temperature, and transport (land-based, such as surface runoff or groundwater; water-based, such as rivers and streams; or atmosphere-based, such as rain and dust).

The study of carbon and its role in global climate change has captured the attention of chemical oceanographers for decades. Since the industrialization of the 18th century, researchers estimate that the amount of carbon dioxide in the atmosphere has increased by 25%. Although scientists cannot yet prove if the increase in atmospheric carbon dioxide has caused global warming or vice versa, it is generally accepted that modern society has added to the amount of carbon dioxide in the atmosphere.

What does all this mean? Since carbon dioxide absorbs infrared radiation (heat), an increase in carbon dioxide in the atmosphere would keep the heat from escaping into space. This would cause the Earth to warm up just as a greenhouse holds heat, thus the popular term "greenhouse effect." Chemical oceanographers are working to understand the ocean's role in this and other theories related to global climate change.

Modern society's rapid technological advances, including the development of complex chemical compounds and processes used to produce and manufacture energy, food, clothing, medicine, and other products, have created a need for chemical oceanographers. In the quest for bigger, stronger, faster, more, the costs of "improvements" often get overlooked. For example, the disposal of waste that results from products and by-products can be a problem in itself. Who would have thought that household cleaning products, fertilizers, pesticides, boat paints, and leaded fuel — all products that saved time, worked better, and often cost less — could have contributed to the degradation of many marine and coastal areas? Fortunately, researchers in many oceanographic disciplines and related areas, including marine chemists, have worked together to improve our understanding of such impacts, which has, in turn, led to improved controls, regulations, and testing methods.

The work of chemical oceanographers will continue to provide answers to important questions. For example, the use of the oceans for waste disposal and as a source for drugs and minerals will require cooperative research between ocean chemists, biologists, and geologists. It is the work of marine chemists that aids ocean engineers in the development of instruments, vessels, and ocean vehicles that, in turn, improve the ability of researchers of all oceanographic disciplines to go to sea, collect data, and discover previously unknown formations, marine life, and phenomena.

Clearly, as the population discovers new ways to use the oceans — be it for food, transportation, energy, or waste disposal — chemical oceanographers will play an important role in improving our knowledge about the impact of these activities on the ocean and its ability to sustain them.

Frank R. Hall • *geological oceanographer*

B.A., earth science, Kean College
M.S., geology, Lehigh Univ.
Ph.D., oceanography, Univ. of Rhode Island

current job: I am an assistant professor in the College of Marine Studies at the University of Delaware with a joint faculty appointment in the geology department. I teach classes in oceanography and deep-sea sedimentation processes, advise students, and conduct research.

My research involves the examination of particles that fall through the oceans to the deep-sea floor. Many of these particles originate on land and travel to the oceans on the wind, in rivers, or in icebergs. These particles are products of regional climatic belts. Over long periods of time, they pile up on one another and result in a vertical record of climate change. In examining these deep-sea sediments, I am really studying how our climate has evolved over long periods of time.

key factor: Originally, I had planned to study history in college. My father, a professor of astronomy, suggested I try geology. I took a class called "Submarine Geology" and I was hooked. It was the most fascinating subject I had ever taken and from that point on I studied everything that involved the oceans and geology. I still study history, but that of the earth and oceans rather than that of man.

like most: Oceanography is a multi-disciplinary subject that includes biologists, chemists, climatologists, physicists, and geologists from all over the world who work together to explore the processes that affect two-thirds of the earth's surface. I like having the opportunity to go out to sea on research vessels with groups of scientists who approach the study of the oceans in different ways. I also enjoy meeting people from all over the world and learning about their cultures and customs.

like least: In order to do my research, I must acquire money, usually in the form of research grants. In order to get a grant, I write a proposal to a foundation or other organization. Often, these proposals are turned down. This can be disappointing. Usually, there are more people writing proposals for research money than there is money available.

relax: I like to exercise, especially lifting weights or playing basketball with friends. I also like outdoor activities, am an avid scuba diver, and like to ride my bicycle. But when I really want to relax, I like to go for hikes in the mountains.

heroes/heroines: I'm not sure if I can properly refer to them as heroes, but there are two people whom I admire. The first is Albert Einstein. I admire him not because he developed the Theory of Relativity, but because as a youth he had to overcome a learning disability in order to achieve what he did. This was at a time when there were no educational programs like we have today for those with learning disabilities.

The second person whom I admire is my father, Alexander A. Hall. There are not many African Americans who've chosen astronomy as a field of study, especially having been raised in the South in the 1920s and '30s. Before learning astronomy, he received a master's degree in chemistry. He never forced his children to study science and allowed us to develop our own senses of what we wanted to be.

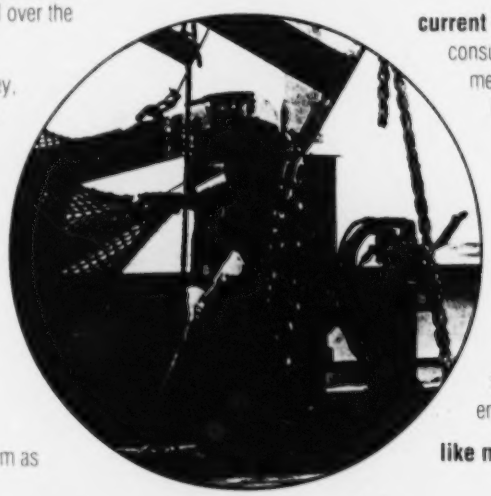
advice: Never be afraid to ask questions, never be afraid to learn, and read, read, read. Go to the library and get as much information as you can. There are many special programs for students interested in the marine sciences. Find information about these programs and see how you can get involved.

career opportunities: Oceanography is a field that deals directly with the environment. While opportunities for people interested in environmental issues are increasing, opportunities in my particular area of research are decreasing. In the past, most scientists went to work at colleges and universities after getting their Ph.D.s. These are typically long-term jobs and the number of people graduating with Ph.D.s is increasing faster than the turnover in faculty positions. However, the trends suggest that by the end of this decade, the number of available faculty positions will increase as older faculty retire. This will greatly increase the opportunities in the field.

10 years: Because I am a relatively young and new professor, I am still in the process of developing a research program. Ten years from now, I will be an established scientist with a full research facility. But most importantly, I will be teaching students, which is what I enjoy the most.

Catherine A. Courtney • *environmental consultant*

B.A., biology, Univ. of California, Santa Cruz
M.A., biology, San Jose State Univ.
Ph.D., oceanography, Univ. of Hawaii



current job: I am an environmental consultant working for PRC Environmental Management, Inc., an international environmental consulting firm. I am responsible for the management and technical direction of the Honolulu, Hawaii, office.

key factor: The decline of funding in academic institutions to support research and a desire to broaden the application of my scientific background to solving environmental problems.

like most: The diversity of the projects

I get involved in — coastal zone management, hazardous waste investigations, environmental law — and the ability to work internationally.

like least: The limited amount of time that I can spend in the marine environment doing field work.

relax: Enjoy a good meal, walk down the beach.

heroes/heroines: Julia Child, because she's funny and loves food.

advice: Get a solid science or engineering background, don't specialize too early in your academic program.

career opportunities: Career opportunities are decreasing somewhat in the U.S. as we continue solving our own environmental problems, but internationally opportunities are increasing as we are able to offer our environmental consulting services to other countries.

10 years: I hope to be working with different countries on coastal area management issues and teaching my daughter how to scuba dive.

Robert C. Rhodes • *ocean modeler*

B.S., atmospheric science, State Univ. of New York, Albany
M.S., meteorology, Texas A&M Univ.

current job: I work for the Naval Research Laboratory at the Stennis Space Center near Bay St. Louis, Miss. I am an oceanographer working on developing ocean nowcast/forecast systems for the Navy. This includes both shore-site and shipboard systems. The goal is to give the Navy a better understanding of vertical temperature, salinity, and current profiles. The systems concentrate on both nowcasts (analyses) and forecasts of the ocean phenomena that are critical for naval applications. The ocean models development entails performing experiments on state-of-the-art super computers and workstations, and graphically displaying the model output to understand the physics of the ocean.

key factor: I have always been interested in weather forecasting. When I first worked for the Navy, I was concentrating on meteorological forcing fields used to drive ocean models, but I became interested in the ocean forecast problem and began to work on the development of operational ocean analysis and forecast systems.

like most: It is a highly technical career that requires working with state-of-the-art computer technology using super computers and high-speed workstations. It allows you to combine physics, mathematics, and computer science to better understand the complex nature of the ocean.

like least: The worst part of the job is constantly having to fight for your funds and defend your project as naval priorities change.

relax: I am active in my local community. I serve on the board of the baseball organization in my hometown of Slidell, La. I coach my children and I also play basketball and golf.

heroes/heroines: I never really thought of anyone as my hero, but I would say that a person who has integrity and a general feeling for others will always be a hero to me.

advice: To become an atmospheric or ocean modeler, it is essential to have a solid understanding of mathematics (including calculus and linear algebra) and physics (motion physics and thermodynamics), and also a real interest and curiosity to understand the physical processes of the ocean and atmosphere. This starts with a solid core of math and science courses in high school. Taking physics and calculus as a high school student will prepare you for the introductory courses in your early college years.

career opportunities: I would have to say that they are decreasing slightly. Because this is an area of research that has always been dependent on government funding, in this climate of decreasing federal budgets, I expect our group to decrease slightly over the next 10 years.

10 years: One of the areas that I have been increasingly involved with has been management. I expect to be working in the ocean/atmosphere models research area, but my focus will be more on program management.

Kay T. Ho • *chemical oceanographer*

B.S., environmental toxicology, Univ. of California, Davis
M.S., environmental toxicology, Cornell Univ.
Ph.D., chemical oceanography, Univ. of Rhode Island

current job: I work as an environmental research scientist at the Environmental Protection Agency laboratory in Narragansett, R.I. I develop methods for determining the toxic compounds in marine sediments. A toxic marine sediment may have over 10,000 compounds in it. I work to determine which of those compounds are toxic. I spend about 40% of my time in the lab, 50% at my desk, and 10% teaching.

key factor: Finding an undergraduate program in environmental toxicology at the University of California at Davis. It showed me there was a way to combine

my scientific knowledge with my interests in the environment.

like most: I enjoy talking with people about science and getting new ideas at conferences. I like to think that what I do might make a difference, and I love it when my experiments work.

like least: The bureaucracy, the paperwork, and how long it takes anything to happen in the government.

relax: I windsurf, run, bodysurf, garden, cook, knit, listen to music, and have big, late dinners with ferocious political arguments.

heroes/heroines: Rosa Parks for refusing to give up her seat on the bus to a white man. Georgia O'Keefe for painting so beautifully. Joni Mitchell for her voice and her lyrics.

advice: Think about going all the way to a Ph.D.

career opportunities: I don't know. I think they should be increasing because of our environmental concerns, but maybe they are decreasing because of our economic problems.

10 years: If I could predict the future, I wouldn't be at this job. All I can say about the future is that I'll still be in the environmental sciences.

Anders W. Andren • *aquatic chemist*

B.S., chemistry, Upsala College
M.S. and Ph.D., chemical oceanography, Florida State Univ.

current job: I am professor of water chemistry in the Department of Civil and Environmental Engineering at the University of Wisconsin-Madison, where I teach and do research on aquatic chemistry. I am also director of the University of Wisconsin Sea Grant Institute. The Institute is involved in research, outreach, and educational activities related to our nation's Great Lakes and oceans.

key factor: An early interest in science combined with a fascination with the aquatic environment. My dad was a sea captain and I grew up by the sea.

like most: Having the opportunity to work with the world's best scientists to better understand our oceans and Great Lakes. Having a chance to influence how our resources, both intellectual and financial, are used to provide guidance to the wise use of ocean and Great Lakes resources.

like least: That I don't spend more time out in the field doing research with my graduate students.

relax: Spend time with my family, play music (guitar and piano), cook gourmet foods, play sports (golf and tennis).

heroes/heroines: My mom and my dad.

advice: Science is a great and rewarding career. Get a good undergraduate degree in a basic science, such as math, physics, chemistry, biology, or geology. When you're in college, try to get a part-time job during the school year or summer in the laboratory of a professor who is in the field.

career opportunities: At the moment, we are seeing a slight decline in numbers of job openings. However, I believe this to be temporary as we move into the 21st century. The supply and demand will always be cyclical, just like in other science and engineering fields.

10 years: Teaching, research, and administration. I cannot think of a better situation where these opportunities exist.

Michael W. Howell • *geological oceanographer*

B.S., aquatic science, Cornell Univ.
M.S., oceanic science, Univ. of Michigan
Ph.D., marine science, Univ. of South Carolina

current job: I am a research associate professor of marine science at the University of South Carolina. I have two major areas of responsibility. As a scientist, I am studying the oceanic and climatic evolution of the Mediterranean Sea during the past five million years. My research involves working in the laboratory and the library as well as fieldwork in many interesting places around the Mediterranean region.

I also direct a comprehensive science education program involving eight South Carolina colleges and universities. Called the South Carolina Alliance for Minority Participation, the program seeks to improve the retention and graduation rates of minority students in the natural sciences, mathematics, and engineering. I oversee the various components of this project. I also travel quite a bit to meet with students and faculty, business and government officials, and my fellow program directors from other states.

key factor: I always had an interest in science and my mother helped support my interests by encouraging the pursuit of my various hobbies (including model trains, model rocketry, tropical fish, photography, chemistry, geology, and biology), enrolling me in various programs that dealt with science, and making sure that I worked hard in school in all of my subjects. Growing up in New York City, I developed quite an interest in things related to the ocean. In high school, I decided to focus my scientific interests toward the study of my favorite subject: oceanography. Therefore, my decision to pursue a career as an oceanographer was based on my desire to study a topic that greatly interested me and provided an opportunity to make a contribution to that field of study.

like most: I enjoy the satisfaction of making contributions of new knowledge to my field of interest as a research scientist. As an educational leader, I enjoy the satisfaction of helping students reach their goals by providing an environment that gives them greater opportunities for success. I also enjoy travelling to various places, meeting new people, and experiencing different cultures (and getting paid to do it).

like least: Many times, you have to make personal sacrifices in order to achieve a certain goal. I often have to give up certain activities and work very long hours in order to finish an activity or project. Although this can be a drag at times, I understand that to be a good oceanographer or administrator, I must be willing to dedicate myself fully to my work. There are no shortcuts.

relax: I enjoy model railroading, learning foreign languages, and gourmet cooking. I also enjoy music, especially the music of the baroque and classical periods. I'm learning to play the organ. Sports have always been an important part of my life and I especially enjoy ice hockey and football. As a student, I also studied karate and learned to scuba dive. While I enjoy being a scientist, I take pride in being a well-rounded individual who can value the work that others do (outside of science) that makes our world so interesting.

heroes/heroines: There are many people who have in some way inspired me to achieve in life, including my mother who certainly had the greatest influence on me. I generally admire people who have either overcome great obstacles to reach their goals or who have broken new ground in some productive endeavor. A good example would be Dr. Mary McLeod Bethune, a distinguished educator who not only had brilliant ideas but also left a legacy that includes an institution of higher learning. She was able to do all of this and win the confidence of the president of the United States at a time when blacks were afforded very few opportunities to achieve.

advice: To be a marine scientist requires a lot of hard academic preparation as many jobs in the field require not only a bachelor's degree, but a master's or doctoral degree as well. You must enjoy science and mathematics as marine science is simply the study of these fields in the context of the ocean. Therefore you must pursue a college-preparatory curriculum that will prepare you to major in some area of science or mathematics. Ideally, you should have at least three or four years of high school science and three or four years of mathematics.

However, you must be a good student in all of your academic subjects. A great scientific discovery you make is not going to be of help to anyone if you cannot communicate your results. Writing and speaking skills are very important and that's where good language arts and English skills will pay off for you. Also, in today's workplace people who can speak foreign languages are always going to be a step ahead.

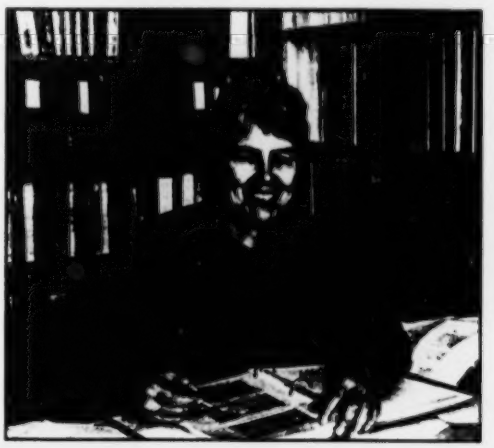
career opportunities: The number of job opportunities has remained about the same over the past few years. However, there definitely have been changes in the job market in terms of where the best opportunities for employment as a geoscientist reside. Those professionals who are involved in environmental or global change studies appear to have the best opportunities. In addition, many opportunities exist for scientists who have broad backgrounds and can work with scientists from other fields. Although employment potential is important when choosing a career, I feel that students should choose a field of study that greatly interests them, and then make every effort to excel in their studies. There will always be jobs available for people who are considered to be the best at what they do.

10 years: I'm not sure as to what I will be doing 10 years from now. I have been fortunate to have had a variety of interesting job assignments that have given me valuable experiences that I can use to move my career in new directions. I can continue my work as a research scientist or as a university administrator or as some combination of both. The important thing for young people to remember is this: getting a good education is always going to give you options when it comes to career choices and job opportunities. You want to take a job because it interests you and you feel you can make a substantial contribution, not because there aren't any other opportunities for you.

Adriana Huyer • *physical oceanographer*

B.S., physics, Univ. of Toronto
M.S. and Ph.D., physical oceanography, Oregon State Univ.

current job: I am professor of physical oceanography at Oregon State University in Corvallis, Ore. My position entails a wide variety of tasks and responsibilities. I am primarily a research oceanographer. I study the currents within the ocean and their response to the overlying winds. The studies are usually complex and sometimes take place in remote regions, so careful planning is essential to ensure that all resources are in place and operational when needed. After the measurement program is well underway or complete, preliminary conclusions are reported orally to colleagues at scientific meetings. Important results are further analyzed, critiqued by external reviewers, and published formally in scientific journals.



On average, I spend about one month per year at sea as part of a team of scientists and technicians. Both men and women make up the scientific team. While on board, we lower instruments into the sea, or tow them through the water, to measure water properties such as temperature and salinity. We collect water samples for chemical analyses to determine nutrient, oxygen, and chlorophyll concentrations. We also measure water velocity directly under the ship by means of acoustic instruments attached to the hull. Most of these measurements are logged directly on computers. While at sea, we study the incoming data to ensure accuracy, to optimize the sampling scheme, and to determine as soon as possible whether incoming results support or contradict our ideas.

My position also entails teaching. I teach about one course per year to

graduate students in oceanography, and I also advise them on their research.

key factor: I cannot say there was one "key factor." Rather, there was an accumulation of many factors: my eagerness to learn and excel; strong support from my parents, siblings, and teachers when I was young; a drive to persevere; a need to earn money; strong support from supervisors in my first professional job; good role models; and good advice while I was a graduate student.

like most: I especially enjoy interpreting the results of recent measurements, particularly when a clear description of a new phenomenon emerges or when a fuzzy understanding of some phenomenon is clarified through observations we have made. I also enjoy writing, and take real pleasure in designing the graphical display of our results.

like least: The thing I like least is having to argue for financial support to cover the costs of the research.

relax: Walk, sew, read, attend church, spend time with friends.

heroes/heroines: Henry Stommel, who brought us much fundamental understanding of ocean currents. And June Pattullo, who was a completely professional physical oceanographer and thereby showed me in person that at least one woman could do it.

advice: Take any mathematics and science courses you can. Be sure to take physics as soon and as often as you can. Do your homework. Spend time outdoors and notice the movements of stars through the sky, trees in the winds, clouds growing and shrinking, waves on the beach. Go to the library, browse through encyclopedias, and read.

career opportunities: I think opportunities are decreasing. Funding for basic research in general and for oceanography in particular is likely to remain at about the same level over the next few decades. The number of scientists in this field has increased markedly in the last two decades, and opportunities for new scientists will be relatively few.

10 years: I really don't know. I hope that younger scientists will have taken on many of the scientific questions that interest me today, questions like: How are offshore and coastal waters exchanged? How can we estimate the lateral exchange of water properties within the upper ocean?

Peter C. Griffith • *biological oceanographer*

B.S., botany and zoology, Duke Univ.
M.S., marine, estuarine, and environmental science, Univ. of Maryland
Ph.D., ecology, Univ. of Georgia

current job: In the past I have worked as a biological oceanographer at the Smithsonian Institution, the University of Georgia, and the Center of Marine Biotechnology in Baltimore. All through my career I have used computers and electronic devices, many of which I built, to answer questions about how communities of plants and animals interact within the natural environment.

Today, however, I work in industry, at a company called North American Collection & Location by Satellite. My job title is business development manager. This means that I get to talk to scientists and business people about how my company can solve the problems that they are facing, using the technology that we already have or that we can develop. We use satellites to measure and observe the natural environment and the activities of humans all over the world.

From my office in Landover, Md., I can tap into a virtual sea of information that includes the current location of a manatee taking a long summer swim from Florida to Long Island, the latest catch by fishing fleets in Peru; the number of volcanic earthquakes in Mexico, and the arrival of a trainload of hazardous chemicals in Chicago. We use our satellites in space and our computers on the ground to give our customers the information they need to achieve their scientific or business goals.

key factor: I grew up on a lake in Florida. If I wasn't snorkeling or looking for frogs, gallinules, and alligators, I was probably inside reading the latest issue of *Popular Science* from cover to cover. I learned to scuba dive during high school and loved the feeling of freedom as I floated among the creatures of the reefs. When I got to college, I was astonished to discover that I could actually study marine biology and biological oceanography. Spending eight months as an undergraduate student at the Duke University Marine Laboratory, surrounded by the marshes and islands of coastal North Carolina, convinced me to make this my life's work.

like most: I particularly enjoy hashing out a problem with someone, learning from them what they consider important and devising a solution that is both technologically effective and economically feasible.

like least: It sometimes takes years to take a good idea and turn it into a fully realized, marketable product of service.

relax: I play with my kids (ages 7 and 4), listen to music, read, swim, fish, or ride my bike. I've given up flying ultralight airplanes and I only occasionally get to scuba dive, but I do still teach race car driving.

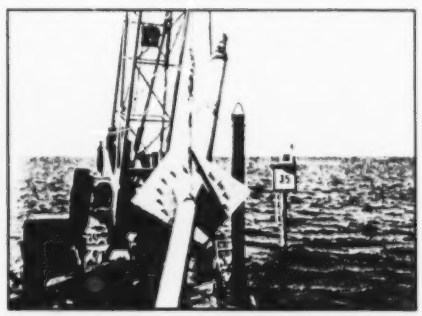
heroes/heroines: I admire most those men and women, famous and unknown, who devote their best efforts to love and work.

advice: Learn as much as you can about how we *think* the universe works. This means studying math, physics, chemistry, computers, and biology. Learn at least one foreign language and learn how to write understandably and expressively. Ask questions all the time. Challenge assumptions. Remember, science is an exploration of a universe that is stranger than we can imagine.

career opportunities: Opportunities are always there for the bright, strongly motivated individual. It will take you another 10 years to school yourself to enter the scientific or technological workforce, and no one can predict what conditions will be at that time. Don't expect to find an easy, guaranteed career path. So, be flexible and innovative and do what you love to do.

10 years: In another 10 years I expect to be managing a team of engineers and business people who are working to devise solutions to environmental problems.

Ocean Engineering



Supported by Sea Grant and the U.S. Coast Guard, University of New Hampshire engineers Ken Baldwin, Pedro de Alba, and Rob Swift, left to right, developed a pile designed to mark navigational channels and survive collisions with tugs and barges. To the left, the researchers study a scale model; above, a Coast Guard crew installs one of the devices in the Houston Ship Channel.

The field of ocean engineering provides an important link between the other oceanographic disciplines such as marine biology, chemical and physical oceanography, and marine geology and geophysics. Just as the interests of oceanographers have driven the demand for the design skills and technical expertise of ocean engineers, the innovations in instrumentation and equipment design made by ocean engineers have revolutionized the field of oceanography. This is especially true within the last three decades.

The invention of thousands of oceanographic instruments and devices, including computer- and satellite-linked buoys and floats, sediment traps, seismometers (instruments that measure seafloor movement in a manner similar to the way seismographs measure earthquake activity on land), underwater video equipment, acoustic measuring devices (instruments that make it possible to "sense" underwater objects and seafloor formations), and underwater vehicles, including submersibles and remotely operated vehicles (ROVs), has changed the way oceanographers study the oceans and coasts. What once took years to measure or sample, frequently in harsh weather, can now be accomplished in minutes, often from remote locations, in the comfort of scientific laboratories. The innovations of ocean engineers have enabled oceanographers to travel farther offshore and deeper into the sea, and to stay there for longer periods of time. Because of ocean engineers, major oceanographic discoveries — including hydrothermal vents, ocean volcanoes, thousands of miles of underwater mountain chains, "new" species, and biological, chemical, geographical, and physical processes and phenomena — have been made.

Ocean engineering is actually a combination of several types of engineering, mixing mechanical, electrical, civil, acoustical, and chemical engineering techniques and skills with a basic understanding of how the oceans work. The importance of

working in partnerships with oceanographers from other disciplines is critical, as the challenge of working in the ocean environment requires a range of backgrounds and skills. The expertise of ocean engineers is invaluable to oceanographers interested in measuring or studying various aspects of the ocean. For example, programmable buoys that can remain at sea for long periods of time have helped physical oceanographers study currents and weather in many locations at once. In addition, the data gathered by these buoys can be relayed back to a laboratory located on a ship or on land, giving the researcher "real-time" data. This is especially important for marine meteorologists.

Not only do ocean engineers design and build instruments that must stand up to the wear and tear of frequent use, they must also take into account the conditions of the ocean environment, such as the corrosive nature of salt water, high winds, waves, currents, severe storms, and marine life fouling (such as barnacles) in their design plans. The marine environment is considered by some to be more hostile than outer space. In addition to ocean engineers, technicians play a key role in maintaining and preparing the equipment. It is the responsibility of technicians to make sure that instruments are functioning properly, recording the measurements they were designed to and, in some cases, that the information recorded is relayed back to satellites or computers that may be hundreds or even thousands of miles away.

Coastal engineering has become an increasingly important part of ocean engineering as coastal oceanography has gained in importance — a trend that goes hand in hand with the growth in coastal populations throughout the world. With more and more people living or working at or near the coast, problems associated with coastal development, such as pollution and waste disposal, will require the expertise and innovation of coastal engineers. For example, increasing a coastal city's capacity to handle the sewage and garbage generated by a growing population requires careful attention to the effect disposal methods will have on the adjacent water bodies. What may work for an ocean-based city may not work for a lake- or river-based city. Also, waves, rising sea level, and storms have a significant impact on coastlines, often causing erosion and loss of coastal property. In efforts to protect coastal structures, coastal engineers are tasked with designing and creating ways to lessen the impact of storms and other natural shoreline processes.

Coastal engineering has become an increasingly important part of ocean engineering as coastal oceanography has gained in importance — a trend that goes hand in hand with the growth in coastal populations throughout the world.

Other areas that involve the human applications side of ocean engineering — versus the strictly science side — are the oil industry, military, and marine navigation fields. Each of these sectors directly impacts our lifestyle in some way, be it a source of energy, transportation, or our nation's defense. The work of ocean engineers plays an important role in each of these employment sectors. Because technology is central to the field of ocean engineering, future career prospects seem promising. And, as the role of the ocean continues to gain the interest of business, government, and the private sector, the demand for ocean engineers should grow.

Experts in the education and engineering fields regard ocean engineering as a very systems-oriented field because of its interdisciplinary nature. As such, they are an important part of the ocean research system — without their expertise, oceanography would be many years behind in terms of what we know about the ocean system and its impacts on our daily lives.

Janice Tarrant • *ocean engineer*

B.S., physics, Univ. of Adelaide (Australia)
M.S., aerospace engineering, Massachusetts Institute of Technology

current job: I am a controls software engineer at the Monterey Bay Aquarium Research Institute (MBARI) in Pacific Grove, Calif. I work on the control software for an advanced remotely operated vehicle (ROV). The ROV, called ***Tiburon*** (Spanish for shark), will be launched from a ship into Monterey Bay and will be able to reach a depth of about 4000 meters. It will be piloted by joysticks from a control console on board the ship. Video cameras mounted on the ROV will show what the vehicle is "seeing" in the ocean. The control software will allow the "pilot" to control the ROV in "flight."

key factor: From watching some of the ***Viking Mars Lander*** film footage, I had the idea that working on space robots would be a really fun job. And I did work on NASA robots for about four years before coming to MBARI. Working with underwater robots is surprisingly similar, but exploring the Monterey Canyon is much more enthralling because of all the incredible creatures that inhabit the ocean depths.

like most: I like the creative aspects of writing software and working on a real physical system like the ROV rather than a computer system. I also like the fact that other people will use my software and it will help make their jobs easier and more productive. It's also a privilege to be able to contribute to a project that will aid in our understanding of the environment and the earth's oceanic ecosystem.

like least: I don't much enjoy doing paperwork. Providing documentation for such a complex system as the ROV is very important, but not very exciting. It's amazing how quickly you can forget exactly what you did in writing some software for a subsystem of the ROV, which is why documentation is absolutely essential. It helps me as well as all the other people working on the project.

relax: I am a dancer and enjoy classical and jazz ballet classes. I also like horseback riding, particularly jumping and cross-country.

heroes/heroines: Kate Bush — singer, songwriter, musician, dancer, performance artist.

advice: In college, keep your studies broad initially by taking physics, math, engineering, and computer science classes. That way you can get a better idea of what you enjoy doing and what you're good at.

career opportunities: They're staying at about the same level in the area of oceanographic research; there are probably more opportunities with commercial companies.

10 years: I hope to still be at MBARI. ***Tiburon*** will be operational soon, but many advanced technologies, such as stereo vision, 3-D computer graphics, and autonomous control, will be added in future years.

Joel W. Toso • *civil engineer*

B.S. and M.S., civil engineering, Univ. of Minnesota
Ph.D., hydraulic engineering, Univ. of Minnesota

current job: I work as a project manager for Barr Engineering Company in Minneapolis, Minn. As a water resources consultant, I help people solve water-related problems. For example, if a city along one of the Great Lakes wanted a boat harbor, we would help them determine if it could be done and how much it would cost. Then, if they choose to do it, we would design it for them. I also teach a few evening courses in engineering at the University of Minnesota.

key factor: Having grown up overseas, I wanted a career that would easily apply to work in other countries. Everyone needs water, so water resources engineering was very appropriate.

like most: The variety. One day I may be outside checking an erosion problem along a lake or stream and the next day I may be back in the office reviewing a design for a new well.

like least: The time pressure. Most everyone wants their project done quickly. Working with several project schedules at the same time can be very stressful.

relax: I enjoy playing soccer or taking canoe trips when I can into northern Minnesota.

heroes/heroines: My heroes include my father, my mother, and my wife.

advice: Work hard in school (math and science are important subjects, but so are writing and speech classes), participate in extracurricular activities like sports and music, try to get a job as an intern or assistant in an engineering company, and talk to engineers about their work.

career opportunities: I think career opportunities in civil engineering are stable currently, but as the need for serious maintenance of the infrastructure (our roads, bridges, buildings, and underground pipelines) becomes critical the job opportunities will grow.

10 years: In 10 years I will be happy doing what I am doing now, but I hope I'll be better at it. It would also be nice to have the opportunity to teach full time.

Diana C. Maes • *civil engineer*

B.S., civil engineering, Univ. of Texas, El Paso

current job: For the last 15 years I have been employed with the Dow Chemical Company at its Texas Operations Manufacturing Facility. Located in Freeport, Texas, the facility covers more than 5000 acres and employs over 6000 workers. My job is to manage administrative activities associated with groundwater investigations and/or remediation. One of my responsibilities is to manage the wetland program. I prepare, review, and submit applications for permits to the Corps of Engineers.

key factor: My freshman math teacher in high school, Mrs. Leticia Chavez, read a newspaper article in class about the need for civil engineers. This was the first time in my life that someone had talked to me seriously about attending college and becoming an engineer.

like most: The many different opportunities. Even though my degree is in civil engineering, I have had the opportunity to work in several different types of jobs. My first job at Dow was construction administration, then I moved to design (structures, foundations) and eventually to project control (project scheduling and cost control). For the last four years I have been involved with environmental projects, including wetlands management. My job has also given me the opportunity to travel.

like least: The paperwork. I have to write many letters for documentation and/or communication purposes.

relax: We have two children, ages two years and eight months, so there is not too much time to relax. I do love to snow ski and I enjoy fishing. I like to read (Spanish/English) books.

heroes/heroines: My parents. Neither one of them had a high school diploma, but both instilled in me the value of hard work. They taught me that if I worked hard enough at everything I would achieve all my goals.

advice: Be dedicated to your school work, participate in team activities, and work on your communications skills.

career opportunities: There will always be a need for civil engineers because they have the basic training to work in many areas.

10 years: On a professional basis, I plan to continue working in the environmental area and managing projects. On a personal basis, I hope to travel with and enjoy my family.

John Buck • *electrical engineer*

B.S., electrical engineering, Massachusetts Institute of Technology
B.S., English literature, MIT
M.S., electrical engineering and oceanography, MIT/Woods Hole Oceanographic Institution Joint Program
Ph.D., electrical engineering and oceanography, MIT/WHOI Joint Program (candidate)

current job: I am pursuing a Ph.D. in the MIT/WHOI Joint Program. I spend the academic year working in the Digital Signal Processing Group on the MIT campus in Cambridge, Mass., and the summer working at WHOI in Woods Hole, Mass. My research focuses on underwater acoustics. In addition to mechanized underwater sound, I have studied dolphin, whale, and walrus sounds in the past. This work involved developing methods for identifying individual animals in a group from their vocalizations.

key factor: My decision to attend graduate school in electrical engineering at MIT was influenced by that department's policy of encouraging graduate students to gain teaching experience. Another factor was having the opportunity to continue working for Prof. Alan Oppenheim, who supervised my bachelor's thesis. I was attracted to the MIT/WHOI program by the exciting research atmosphere in Woods Hole, specifically the opportunities for interdisciplinary interactions among researchers.

like most: Oceanography is an exciting field because it combines intellectual challenges with physical adventure. There is a tremendous amount we do not yet understand about the world's oceans, and striving to understand more is an exciting challenge. I also enjoy the practical aspect of the work. The ocean provides us with a concrete testing ground for our ideas. I like having the opportunity to apply my signal processing knowledge to problems in other disciplines, such as underwater acoustics and marine mammal calls.

like least: Much of the research is funded by the Department of Defense, which means it is easiest to get funding to work on topics of interest to the military. These topics may not always be the ones you personally find the most interesting. Also, at many educational institutions, teaching excellence is not as highly valued as the ability to attract research funding. I am fortunate that my department at MIT does support and reward effort in the classroom. However, as I look ahead to finding a faculty job at another school when I graduate, I am concerned about the fact that many schools do not.

relax: I enjoy playing sports to relax, mainly ice hockey, lacrosse, and ultimate frisbee. I jog. I also play bass in a rock band with several of my friends. Boston is a great city for both theater and music, and I try to get out to see both as often as I can. I try to make time to read good books.

heroes/heroines: Two of my heroes are St. Thomas Becket and St. Thomas More. Both

were men with the moral courage to stand up for their beliefs in the face of public opinion.

advice: You can't learn enough math. No matter what field you are in, math will always be useful. Particularly in marine mammal studies, there are people whose research has been limited by their mathematical backgrounds. In my experience, it is much easier for someone with a strong math and engineering background to acquire the relevant biological background to collaborate on these topics than for most biologists to attain the level of engineering expertise to investigate the questions they are interested in.

career opportunities: Whether I think of my field as education or underwater acoustics research, I would have to say that opportunities are decreasing or at best staying level. Both fields have felt the cutbacks in government funding for basic research. In education, many universities are not hiring new professors and some are not replacing current ones who retire. It is possible that opportunities will increase in marine mammal science due to the recent awareness of the possible effect of acoustic experiments on these animals. It is likely that most future acoustic experiments will include coincident studies of the impact of the experiment on marine mammals.

10 years: I hope I will be a professor of engineering at a smaller college emphasizing undergraduate education. In addition, I hope to continue my research connections with the people I have worked with at Woods Hole by returning to work there each summer.

Gregory D. Boardman • *environmental engineer*

B.S. and M.S., civil engineering, Univ. of New Hampshire
Ph.D., civil engineering, Univ. of Maine

current job: I am an associate professor of civil engineering at Virginia Polytechnic Institute and State University in Blacksburg, Va., where I teach and do research on topics related to environmental engineering. My current research projects include the development of a robot that could work at hazardous waste sites, the study of ways to reduce water pollution, and an investigation of the treatability of wastes from several sources.

key factor: The fine faculty members I studied under at the University of New Hampshire and the University of Maine were key factors as was my desire to be involved in protecting the environment.

like most: The diversity of issues, working with young people, the opportunity to help solve environmental problems, and training others who can help.

like least: I never feel like I'm done. There's always another problem, another paper to write, more things to do. When I'm tired, these are the things that I like least. When I'm not tired, these are among the things I like best.

relax: Years ago, I used to hunt, fish, play ball, and play golf. In recent years, I've coached girls softball and basketball, and have been involved in a number of church activities, such as helping to establish local programs for homeless families.

heroes/heroines: The great scientists, like Albert Einstein. People who have dedicated their lives to helping others, such as Mother Teresa. Average citizens who work hard, are honest, and make things (cars, plumbing, etc.) and systems (town commissions, mail, etc.) work. Optimists.

advice: Take plenty of math and science, and learn to use the computer.

career opportunities: Increasing. The scope of environmental science is very broad and we need to take good care of our world. The work force needed is large and the problems are difficult, so there will always be a demand for good, fresh ideas and people.

10 years: I may become a university administrator, rather than a teacher and researcher. Sometimes I think of becoming a full-time engineering consultant (I do part-time consulting now.), but I think I would miss my interaction with college students. They make me feel young and I learn from them as well.

Kelly A. Rusch • *aquatic engineer*

B.S., biology and chemistry, Univ. of Wisconsin, LaCrosse
M.S. and Ph.D., civil engineering, Louisiana State Univ.

current job: I am an assistant professor in the Department of Civil and Environmental Engineering at Louisiana State University in Baton Rouge. My primary responsibilities are to solicit research funds, perform research, and advise graduate students. My specialty is recirculating aquaculture technology, which entails finding better ways to raise fish in tanks as a food source. My major current effort involves the development of a computer-based system for raising algae to feed larval fish. This system will save the aquaculturists time and money, and it will also benefit other commercial ventures that use a great deal of algae, such as the pharmaceutical industry.

key factor: I have always enjoyed the academic setting. While I enjoy both teaching and research, my current position is providing me with an opportunity to expand my research experience.

like most: I enjoy both my research and the opportunity I have to teach.

like least: Paperwork and bureaucracy. This takes a tremendous amount of time away from my research and teaching.

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relax: Hunt, fish, play racquetball, read.

heroes/heroines: I really haven't given this much thought.

advice: I would tell them to make sure they had a solid background in math and the hard sciences (biology, physics, chemistry). If the student was female, I would definitely encourage an engineering career to increase the number of women in this field.

career opportunities: I feel they are increasing as a whole, especially for women.

10 years: I will be a tenured faculty member at a major research university.

Frank L. Kudrna • *civil engineer*

B.S., engineering, Chicago Technical College
M.S. and Ph.D., city and regional planning, Illinois Institute of Technology
M.B.A., Univ. of Chicago

current job: I am president of Kudrna & Associates, a civil engineering firm of approximately 35 people specializing in civil engineering and water resource-related work. We have two offices, one in Chicago and one in Westmont, Ill. We work for both public and private clients and we get involved in the construction of water systems, roads, marinas, sewers, and golf courses.

key factor: I loved math in school, and science was a close second.

like most: I enjoy solving problems, the more complex the better.

like least: When you run a company as an entrepreneur, you work a lot of hours. There is always something else to do.

relax: I love the Great Lakes (as you can see from the picture) and have been chairman of the Illinois delegation to the Great Lakes Commission, an organization that coordinates economic and environmental activities involving the eight Great Lakes states, for almost 20 years. My wife JoAnn and I have a weekend home on Lake Michigan in Indiana. We love to go there and swim and walk and enjoy the ever-changing Lake Michigan.

heroes/heroines: Theodore Roosevelt, Frederick Law Olmstead, and Bart Simpson (just kidding about Bart).

advice: Take the tough math and science courses and get a leg up on college. Go visit some engineers working in the fields you think you might be interested in and see what they do. Talk to them.

career opportunities: Career opportunities in engineering, and especially in civil engineering, are increasing. America has neglected its infrastructure and the need to rebuild sewers, water mains, waste water plants, roads, water fronts, etc. is enormous. This will be a strong career into the future.

10 years: I expect to be spending much more time observing Lake Michigan and relaxing. The Great Lakes are my hobby and I expect to continue to be involved in activities like the Great Lakes Commission and the National Sea Grant Program. I might do a post-doctorate and a little research or teach a class. Whatever I do it will be near the water.

Reinhard E. Flick • *oceanographer*

B.S., physics, Cooper Union
Ph.D., oceanography, Scripps/Univ. of California, San Diego

current job: I work for the California Department of Boating and Waters, and I am stationed at the Scripps Institution of Oceanography in La Jolla. While my training is in oceanography, much of what I do is more closely related to coastal engineering. This work involves monitoring the impact the ocean has on the state's coastline and coastal structures. I oversee the Department of Boating and Waters' research program and am also involved in public service and my own research projects.

key factor: I was looking for a field where I could apply physics principles to more practical earth and ocean science problems.

like most: The relative freedom, both physically (flexible work hours and schedule) and mentally (choice of research topics).

like least: The income potential is limited. Public employment, including federal, state, and university, is less secure than it was when I was job hunting nearly 20 years ago.

relax: I work on classic cars, hike, ski, and lift weights.

heroes/heroines: Dr. Bob Guza, a colleague who always cuts through the bull to the heart of any question and is always generous with his time, particularly for students.

advice: Develop entrepreneurial skills and look more toward private sector employment than toward public sector or academic employment.

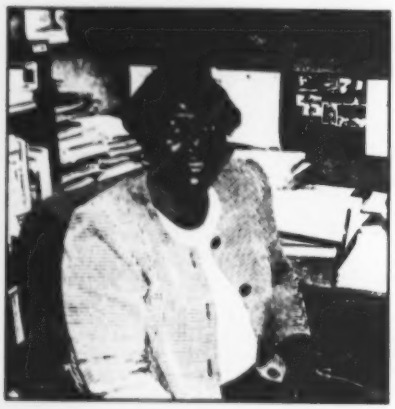
career opportunities: They are either

decreasing or at best staying level because of decreasing funding levels.

10 years: Same as today, but looking toward private sector or self-employment. Depending on conditions, I may move in that direction sooner.

Glenda K. Ashford • *environmental engineer*

B.S., civil engineering, Southern Univ.
M.S., environmental engineering, Georgia Institute of Technology



current job: I am with the South Atlantic Division of the U.S. Army Corps of Engineers. Working out of Atlanta, Ga., we are involved in the management and improvement of rivers, harbors, and waterways for navigation, flood control, shore protection, and other purposes. My responsibilities include program management, planning, analysis, technical consultation, quality assurance, coordination, oversight of field activities, and problem solving. I routinely handle environmental issues relative to the impact of Corps' activities on endangered species such as sea turtles, fish and wildlife resources, coquina rock outcrops along the Atlantic Coast, wetlands and other natural ecosystems, water quality, cultural and natural resources, and hazardous and toxic waste.

key factor: The physical and human environment as we know it is undergoing rapid and in some cases detrimental changes. I feel it is my duty as a citizen and public servant to protect and preserve our environmental resources. In keeping with this personal commitment, I have chosen to pursue a career in environmental engineering.

like most: I can influence changes in projects to protect, enhance, or restore the environment.

like least: The steps that I can take to preserve and protect our environment are very small in relationship to the magnitude of events happening around the world that could harm our environment and potentially threaten our quality of life.

relax: Between pursuing my career and rearing three very active daughters, I don't always find a lot of time to relax. I enjoy spending quiet time and vacationing with my children in a slow-paced, relaxing environment. I also enjoy reading.

heroes/heroines: Dr. Martin Luther King Jr., who was an advocate of and major impetus behind social justice and change in this country and elsewhere. I am inspired by his leadership abilities, including his ability to motivate people to work toward a common goal. I admire and respect his accomplishments.

advice: As in most engineering fields, personal interest and a good solid background in math and science are prerequisites to success.

career opportunities: Career opportunities are fairly stable. There is a recognized and long-term need for environmental experts. Creative individuals with innovative ideas on cost-effective and efficient technologies for solving environmental problems will be in great demand.

10 years: My long-term goal is to be in a position where I can affect the development of policy, laws, and regulations designed to protect, enhance, and restore the environment.

Joseph H. Comer III • *marine architect*

B.S.E., naval architecture and marine engineering,
Univ. of Michigan

current job: I am design group manager at the Bender Shipbuilding and Repair Company in Mobile, Ala. I am responsible for managing the development of designs for various marine vehicles. Our group enters the design spiral at any point from concept design to the preparation of detailed production drawings. We utilize many aspects of CAD/CAM technology to produce these designs.

key factor: At a very early age I fell in love with the saltwater environment and boating. As I got older this inspired the desire to live and work near coastal areas. Although my first marine-related jobs were not in the engineering field, those experiences served my career well in later years.

like most: Living in a lovely coastal area where my personal enjoyment of marine activities and my professional goals are synonymous. Being constantly involved with the production of my designs.

like least: The pressures of time and budget and applying those pressures to our employees.

relax: Reading, sailing (both in competition and for pleasure), water skiing, duck hunting, fishing, and just messing around with boats.

heroes/heroines: Frontiersmen, seamen, adventurers. The people, even today, who are willing to go the extra mile to accomplish a goal or task that is just beyond their reach are the people I consider heroes.

advice: Find out as much as you can about the marine industry by visiting companies and related universities, observing marine products, and reading. Or, fall in love with the sea.

career opportunities: The sea is our last great frontier, and naval architects and marine engineers will lead the way.

10 years: Sailing!

Related Fields

Marine educators design programs to teach young and old about our aquatic resources. Here, a group of grade-schoolers from Michigan participate in the Great Lakes Education Program. The program was developed by Michigan Sea Grant to introduce students to the biological, physical, chemical, and cultural aspects of the Great Lakes and other aquatic systems.

There are many jobs in the field of marine science that do not fit into the categories of marine biology, oceanography, or ocean engineering. Instead, these jobs may fit more than one category, or they may overlap other fields, such as education, communication, economics, seagoing careers, or business.

Many of these jobs are highly specialized and require very different educational backgrounds, experiences, and skills. Some of the jobs were created by the people who hold them — in other words, they may have started their own business or created their position because they saw a need for their expertise and pursued it.

Some common characteristics of people in virtually all marine-related careers seem to be a love for the sea, a respect for the way the ocean works, and a sense of curiosity. Many people in the various fields of marine science describe a feeling of accomplishment or satisfaction about their work, knowing that being involved in their field has or will make a difference for present and future generations.

There are countless possibilities within the marine-related field: marine educator, science writer, filmmaker, photographer, ecotourism guide, park ranger, beach superintendent, maritime or environmental lawyer, aquavet (veterinarians that specialize in marine or aquatic animals), economist, marine archaeologist, marine historian, fundraiser or spokesperson for a marine organization, museum, or non-profit group, aquaculturist, manager of a local, state, or federal agency specializing in marine or freshwater issues, marina manager, ship's captain or mate, environmental planner for a town, city, or state, manager of a land conservation organization or land trust, botanist, computer specialist with a marine or environmental organization, ecologist, hatchery specialist, landscape or maritime architect, and so on.

While we certainly won't attempt to list all of the possibilities for a marine-related career, it's probably

safe to say that you can combine your interest in the ocean or freshwater with many other fields to design a potential career.

As many different career opportunities as there are in the marine field — especially the "related fields" — there are almost as many different pathways to achieving such a career. For example, there is no set pathway to becoming an underwater filmmaker, as you will read in Bill Lovin's profile on page 32. His advice to aspiring underwater filmmakers: "First, learn to be the best diver you can be, completely at home in the water. Second, don't major in film or television in college. Take marine biology or journalism, or even business. Learn a lot about a lot of things. . . You will have to 'make' your job because there are few (perhaps no) jobs out there at any given time. . ."

If you like to write and you have a love for the water, ocean, or environment, a career in environmental reporting, science or technical writing, communications, or public relations may be career choices worth exploring. If you are a "people person," enjoy teaching and public speaking, and don't mind working long hours, a career in marine education — either in the classroom or at an aquarium, museum, nature or science center, park or wildlife refuge — may be for you.

If you love the beach, swimming, and working with others, there is a way to go to the beach every day and still be working — just ask Brian Keaulana, a lifeguard supervisor in Hawaii (see page 33). Or, if you're torn between your interest in a career in law and a position in the marine field, consider a career in environmental or maritime law.

The work environment is another important factor to consider. Marine-related job opportunities exist in virtually every setting: within local, state, and federal government, private industry, academia (schools, colleges, universities), business, and non-profit organizations, to name a few. The positions available may be similar, but the actual day-to-day responsibilities can differ greatly, depending on which avenue you choose. For example, a ship's captain could choose to work for the federal government commanding a U.S. Navy ship,

Some common characteristics of people in virtually all marine-related careers seem to be a love for the sea, a respect for the way the ocean works, and a sense of curiosity.

a private oceanographic research institution commanding a research vessel, or a museum or aquarium commanding a visitors tour boat. While the job title may be similar, the job description could vary greatly.

Another thing to consider is where you'd like to work. Not all marine-related jobs require you to live at the coast, though many opportunities will be near it. Locations around freshwater, such as rivers and lakes, also offer similar career opportunities.

And, don't forget, the best job will be one that combines your interests and skills. Consider what makes you happy. Do you like: working independently or do you prefer being around others? working at your own pace or in a more structured environment? flexible or odd hours? a typical work day with a lunch hour, paid vacations, and sick time? traveling or staying close to home? supervising and leading others or reporting to a supervisor? working in a team setting? being outdoors in all weather conditions, inside at a desk, or a combination?

Having a career that makes you feel good about yourself and your responsibilities is very important. Consider your interests and hobbies while thinking about your career options. After all, it wouldn't be enjoyable to get up and go to work every day if you didn't like what you were doing. Marine educator Dayna Reist notes (see her profile, page 31), "I studied marine biology in college, but I found that my interest did not lie in the hard-core science aspect of this field. I began taking courses in education and I discovered that working with people was of much greater interest to me than working in a laboratory. I investigated museums and aquariums, and found that most of them have education departments that teach about the marine world. This is the perfect setting for me. I have the opportunity to share my delight and interest in marine science with people while at the same time being surrounded by the animals and environment that I have always loved."

Just as learning about the different fields of oceanography is important to scientists and technicians who conduct marine research and strive to understand how the oceans work, learning as much as you can about the ocean and the environment is important in the marine-related field as well. A career in any aspect of marine science involves a life-long learning process. Because oceanography is a relatively new science, there is a great deal yet to be discovered and understood. What an exciting field to be in!

Cindy Zipf • *ocean advocate*

B.A., marine policy, Univ. of Rhode Island

current job: I am executive director of Clean Ocean Action (COA). COA is a nonprofit ocean advocacy organization consisting of 150 fishing, boating, diving, conservation, and civic groups concerned with the water quality of the New York Bight — the area of water from Montauk Point, N.Y., to Sandy Hook, N.J. COA operates two offices, one on the northern end of the New Jersey coast at Sandy Hook and one on the southern end at Cape May. COA uses education, research, and public pressure to enact measures to clean up and protect ocean waters.

key factor: Before joining COA, I was an intern at a marine lab. Part of my job was to expose marine animals to pollutants and watch how they reacted. When exposed, the animals would often try to jump out of the tank, obviously experiencing great distress. I have a great respect for science, however after seeing that I decided to do everything in my power to try to protect the marine environment from pollution.

like most: I like working with the many different people that share a common thread — a strong love for the ocean environment. Groups as diverse as commercial fishermen, senior citizens, elected officials, and local businesspeople coming together to fight for the ocean make this job extremely rewarding.

like least: I find it frustrating at times working with lethargic and sometimes apathetic government bureaucracies. Many times the people in these agencies are professional bureaucrats who do not seem to care about the resource that they are suppose to be protecting. However, there are other government employees who are committed to their jobs and are a pleasure to work with. Long hours and minimal personal time are also negatives.

relax: I relax by gardening or working on my house in Neptune, N.J. I also enjoy sailing, windsurfing, and bodysurfing.

heroes/heroines: My heroes include Rachel Carson, Ralph Nader, Edward Abbey, and Beth Millemann (executive director of Coast Alliance, an advocacy group based in Washington, D.C.).

advice: Have a deep personal commitment to the cause you choose, a technical background in the field, and little interest in making a lot of money.

career opportunities: Career opportunities in environmental advocacy are probably on the rise with the increased environmental awareness worldwide.

10 years: COA's goal is to put itself out of business. However, with the current ocean pollution problems it looks like COA will be around for some years to come.

Daniel S. Schwartz • *research vessel captain*

B.A., psychology, Univ. of Chicago

current job: I serve as master (commanding officer) of the U.S. research vessel ***Seward Johnson***, a ship owned and operated by the Harbor Branch Oceanographic Institution of Fort Pierce, Fl. This ship was built in 1985 and is the only U.S.-flagged research vessel designed to embark, transport, and deploy at sea a piloted deep-diving research submarine. These highly specialized vehicles permit scientists to explore the ocean depths and conduct undersea experiments down to 900 meters (3000 ft.). The ***R/V Seward Johnson*** performs scientific research missions all around the world in marine biology, geochemistry, physical oceanography, geology, and hydrography. In addition to my seagoing duties, I also pilot aircraft on projects for coastal environmental monitoring and oceanographic support.

key factor: My decision to embark upon this career was probably the result of two complementary personality traits: a love of the sea and seafaring and a thirst for responsibility. I felt a need to involve myself in endeavors that could somehow be of service to our nation and mankind. I believe that being a part of the quest to understand the forces that shape our planet is a worthwhile pursuit.

like most: The most satisfying aspect of this career is the individual relationships it has led to and the opportunities I've had to work with an interesting and diverse group of scientists, technicians, students, professors, and researchers of every race, nationality, gender, and creed. The travel and exposure to varied cultures and climates are a big plus, but it is the "gratis" education I have received from the scientists embarked on my ship that has made this a wonderful career choice.

like least: The most difficult aspect of a seagoing career is the long absences from family, friends, and loved ones necessitated by the long deployments that are an essential part of the job.

relax: I am a voracious reader. My personal tastes tend toward history and historical fiction. I am also an amateur radio operator, or a "ham," and on a ship this hobby provides the additional advantage of being able to keep in touch with friends and family from anywhere in the world. I place a high importance on physical fitness and exercise, and for the last 18 years I've been a student of Japanese Shotokan-style karate. I enjoy flying small airplanes and helicopters and visiting museums with antique aviation exhibits. Perhaps most of all, I love to work on and occasionally sail my 27-foot sailboat.

heroes/heroines: Quite a few heroes have inspired me along the subconscious path to this career. Some of my early readings of such

explorers as Arctic adventurer Adm. Byrd and British explorer Capt. James Cook fired my youthful imagination. Early aviation pioneers such as Lindbergh and the ***Mercury 7*** astronauts affected my choice of endeavors. During some of the more tumultuous years of this century, social leaders such as Martin Luther King and Adm. Elmo Zumwalt (who opened the U.S. Navy to full, real equal opportunity) were heroes to me, no less than such commanders as Gen. George Patton, Adm. "Bull" Halsey, and Joint Chiefs of Staff chairman Gen. Colin Powell. More recently, ***Challenger*** astronauts Christine McAuliffe, Judith Resnik, Ron McNair, and their colleagues — Scobee, Onizuka, Smith, and Jarvis — became tragic heroes to me. In that grim winter of 1986, my ship spent two and a half months combing the cold Atlantic seafloor for wreckage from their space shuttle, eventually finding the O-ring seal that precipitated the disaster. Young people today will find no shortage of heroes and heroines as they explore the human and environmental challenges our planet faces.

advice: Read, explore, and ask questions about the world around you. Take an active role in your own voyage of discovery, don't wait for it to come slickly packaged like an Indiana Jones movie or a rock video. Real physical adventures on and under the sea, in the air, and in space are far better that the Hollywood versions. But to get there, you must pursue your dreams with self-discipline. If you want to swim with dolphins, you must accept hours of studying biochemistry; if you want to sail your own command into foreign ports, you must master geography and spherical trigonometry. Rather than looking at education as a chore, you must begin to see the learning as part of the doing, as part of the adventure.

career opportunities: Career opportunities in this field ebb and flow. Federal support for basic science research is under increasing scrutiny along with that for many other worthwhile programs. Yet, there are grounds for cautious optimism. The challenge for the first decades of the 21st century will be how to reconcile Earth's exploding population with an increasingly stressed planetary ecosystem. Some of the answers will lie within the oceans, and the next generation of marine scientists will have to pursue these answers on seagoing research vessels.

10 years: My crystal ball is a bit murky. I may be teaching younger oceanographers and seafarers some of what I've learned or I may be in a shore-based management position, doing the less exciting but still vital support functions that keep research vessels afloat and functioning. I may be back in graduate school, studying marine and ocean policy and wrestling with the conflicting claims for the 200-mile Exclusive Economic Zone. Or I may just still be on the bridge of my research ship, scanning new horizons for whales or manatees or Gulf Stream gyres.

Dayna B. Reist • *marine educator*

B.A., zoology, Univ. of New Hampshire
M.A., education, Bank Street College of Education (candidate)

current job: I teach marine science programs to visiting school children and family groups at the Aquarium for Wildlife Conservation in Brooklyn, N.Y. I also conduct off-site programs, develop new programs, write grant proposals, and conduct teacher workshops.

key factor: Since I was a child, I have been interested in marine science and the animals that live in the oceans of the world. I studied marine biology in college, but I found that my interest did not lie in the hard-core science aspect of this field. I began taking courses in education and I discovered that working with people was of much greater interest to me than working in a laboratory. I investigated museums and aquariums, and found that most of them have education departments that teach about the marine world. This is the perfect setting for me. I have the opportunity to share my delight and interest in marine science with people while at the same time being surrounded by the animals and environment that I have always loved.

like most: Teaching people, especially children, is very rewarding. Seeing the excitement in a child's eyes the first time he or she touches a crab or seastar is unforgettable. Helping people understand the importance of protecting the ocean and its inhabitants makes me feel that I'm doing my part to help the earth. In addition, everyday I get to gaze into a 14,000-gallon coral reef tank as well as to be involved in such events as the birth of a baby whale or the rescue of an orphaned walrus.

like least: Never being able to work with the same group of children or adults twice and never having enough money to do all that we would like to do for our visitors.

relax: I am an avid roller blader and in addition to using them for basic transportation, I play on a roller blade hockey team. I also play the steel drums in a band that plays a mixture of Caribbean and rock-n-roll classics.

heroes/heroines: Jill Kinmont, who was a downhill ski racer in the mid-1950s. She was a contender for an Olympic metal when she crashed during a race and ended up paralyzed from the neck down. She later became a teacher at an Indian reservation in California. Her dedication to her sport and later to her rehabilitation and teaching career is a great inspiration to me.

advice: Volunteer. Museums and aquariums always need volunteers, especially in their education departments, and this is an opportunity for students to become very involved in all aspects of the job. It is the best way for them to find out if they are interested in the field.

career opportunities: This is a competitive field due to the lack of financial support, but I think the situation will improve in the future. More and more people are realizing that education plays an important role in museums, zoos, and aquariums.

10 years: While I see myself working in education, I might move into a school setting so that I could work with one group of children. However, I would always want to include museum, zoo, and aquarium education in my curriculum because I find it so valuable.

Bill Lovin • *underwater filmmaker*

B.A., journalism, Univ. of North Carolina, Chapel Hill

current job: I produce natural history, educational, environmental, and entertainment films and videos about the marine world for television and for the classroom. I have my own company and do a little of everything — diving and shooting, editing, writing scripts. I live 150 miles from the coast in Chapel Hill, N.C., but my work takes me all over the world.

key factor: Realizing that it was possible. Lots of people think this would be a wonderful thing to do, but most think that it isn't possible for them. You have to decide that you can do it and be willing to put in the work and time required. Only a handful of people in the world actually make a living doing this, so it isn't something you waltz into.

like most: The satisfaction of creating. Filmmaking is an art and like any artist, I get satisfaction from the act of creating something I believe in.

like least: The need to sell myself. I hate to self-promote and wheel and deal with "suits." I have agents who sell my work, but even dealing with them is a pain. The business aspects are the worst.

relax: I work all the time. This is not a career for well-rounded people who like to balance their careers with family and friends. All my friends are in the business. The only really relaxing part of my work is diving. I love to dive and shoot film underwater. It's like a hunt without killing anything. It is really satisfying and fun to bring back great images from the hunt. Diving is my relaxation, but unfortunately it's the smallest part of my work.

heroes/heroines: Thomas Edison was a boyhood hero — a hard working and unrestrained thinker. Also Werner von Braun, the German rocket scientist who helped start our space program. Currently, I would have to say that I most admire Dr. Sylvia Earle, whose contributions to life cross many disciplines. In my work, there are many people I respect but no heroes.

advice: Deciding you want to be an underwater filmmaker is a little like deciding you want to be a rock star. Many are called, few are chosen. First, learn to be the best diver you can be, completely at home in the water. Second, don't major in film or television in college. Take marine biology or journalism or even business. Learn a lot about a lot of things. Take up still photography and learn all you can on your own. Then buy a movie camera or video camera and go out and shoot. Learn to critique and edit your own work. You will have to make your job because there are few (perhaps no) jobs out there at any given time. Becoming a self-supporting underwater photographer or filmmaker is possible, but difficult. Always have a second career option!

career opportunities: Being an underwater filmmaker is different than being an underwater videographer. Filmmakers produce products, a videographer goes out and shoots something. There are no jobs in this world for underwater filmmakers; you work for yourself and sell your shows. However, with more cable channels and more interest in the environment, there are more outlets for your work.

There may be a few jobs for underwater videographers with oil companies or hull inspection services, with tourist operations, or even with research outfits. But not many and they may not be full time.

10 years: I hope to be doing exactly what I'm doing now. I hope to be doing it smarter and better. Diving can take a physical toll on a person and my hope would be that no diving accident would prevent me from doing what I love in the future.

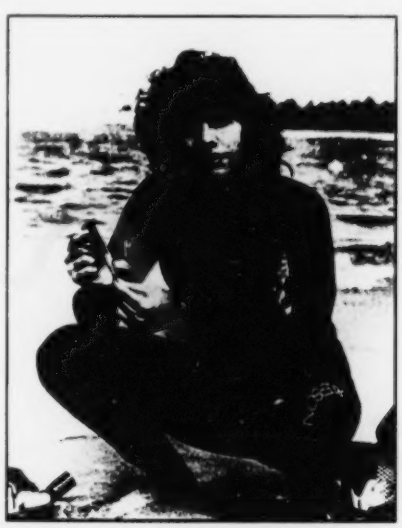
Carmen M. Márquez-Marín • *archaeologist*

B.S., anthropology, Univ. of Puerto Rico
M.S., nautical archaeology, Texas A&M Univ.
J.D., law, Univ. of Puerto Rico (candidate)

current job: I operate my own business, Archeo Marine Research, in San Juan, P.R. I am a consultant and researcher in maritime archaeology. My clients are mostly developers and government agencies that must comply with government requirements in order to be able to build structures on the shoreline or in the sea. I'm also a teaching assistant at the University of Puerto Rico, and during the summers I work as a diving instructor.

key factor: The decisive factor was definitely my passion for the sea, which I developed during my early childhood. My curiosity regarding human behavior also influenced my decision.

like most: I like having the opportunity to combine my interest in human behavior and my love of the sea while studying how human beings have interacted with the marine environment at different times in history. And, I get to spend a great deal of time under water.



like least: This field is relatively new, and it can be frustrating to deal with people who do not understand its importance. Even worse is running into treasure hunters with no respect for history.

relax: Mostly, I go to the beach. I love sail sports: windsurfing, sailboating. I enjoy diving and being submerged for long periods of time, but I always follow the recommended decompression guidelines. On land, I enjoy horseback riding, the movies, and the theater.

heroes/heroines: I don't have a particular hero, but I admire the Mexican painter Frida

Kahlo, Amelia Earhart, and all the other determined, creative, and courageous women who were not afraid to make career choices when there were very few opportunities and lots of restrictions and limitations for them.

advice: Persevere and make your dreams come true. Maritime archaeology is a fabulous discipline and it's new. Many adventures await you, as do long hours reading books in the archives and preserving archaeological pieces in the lab. The work is hard, but the effort is worthwhile.

career opportunities: Opportunities in the field of maritime archaeology are definitely on the rise. As I mentioned earlier, it's a new and unfamiliar field to many. In Puerto Rico, for example, I was the first person to select this career. Although two other archaeologists followed my footsteps, the shipwrecks to be explored and the research to be undertaken in relation to the island's maritime history are considerable.

10 years: I'll probably be working as a lawyer specializing in environmental law. This branch of law includes maritime archaeology and also provides the tools for developing legislation to protect archaeological findings. I hope to continue offering consulting services through Archeo Marine Research. My most precious dream is to create a nonprofit maritime archaeology research institute in Puerto Rico in order to explore and investigate the territorial waters of the island and the Caribbean.

Gary W. Yohe • *marine economist*

B.A., mathematics, Univ. of Pennsylvania
M.A., mathematics, State Univ. of New York, Stony Brook
M.Phil. and Ph.D., economics, Yale Univ.

current job: I am a professor of economics and director of the John E. Andrus Center for Public Affairs at Wesleyan University in Middletown, Conn. The "director" part of my job consists of overseeing the operations of a building that houses Wesleyan's departments of economics, government, history, and sociology. The "professor" part of my job entails teaching and research. I investigate the causes and consequences of global environmental change (this includes the driving forces of global warming and the potential economic damage of the resulting sea level rise). My work as a professor also includes traveling to meetings of various national and international research organizations, sitting on a variety of advisory panels, and seeking funding for my research.

key factor: I chose to enter academics because I thought that I would enjoy a teaching career. I did not understand what research was all about when I made that decision, but quickly learned that it was part of the deal. I gave it a try and found that I liked doing research — probably more than teaching — and I have had some measure of success since then.

like most: I like the challenge, of course. But I like the freedom to set my own agenda and plan my own time the best. It allows me the opportunity to spend more time with my family and children.

like least: This is easy. Traveling to one more conference on climate change. We need a moratorium so that we can stay home and get some new work done.

relax: Play with my children. Work in the yard and garden. Play golf. Travel with my family and, sometimes, with just my wife.

heroes/heroines: My heroes are people who achieve more than a high degree of proficiency at what they do — they bring something intangible to their work that sets them apart. There are a lot of people who hit golf balls as well as Jack Nicklaus, but nobody has ever won more major tournaments. There are a lot of very competent economists, but few can claim to rival Jim Tobin in insight, intuition, and an ability to bring the best out of colleagues. Dennis Connor. Robert Kennedy. People like that.

advice: Learn how natural and socioeconomic systems interact and work alongside one another. Increasingly, employers will be looking for people who can make the connections across many disciplines and subjects even as they become expert in one specialty.

career opportunities: For well-rounded and educated scientists, career opportunities will explode in the coming years. Economists who can work on the interface of the social and natural science disciplines will be in increasingly high demand. Marine scientists who can communicate with economists, sociologists, policy makers, educators, and others will be in equally high demand. On the other hand, opportunities in very narrow specialties may well decline.

There should also be an enormous demand for science writers who can explain the most advanced concepts of natural and social science in terms that people can appreciate.

10 years: I don't really know. The beauty of an academic career is that an academic can evolve as a scholar. He or she can choose what to do and what not to do. It is possible to change directions and focus, almost on a dime. I am sure, however, that my interests will not stray too far from environmental and resource economics. I expect to be participating in an increasingly international effort to develop appropriate response strategies for dealing with global warming and sea level rise.

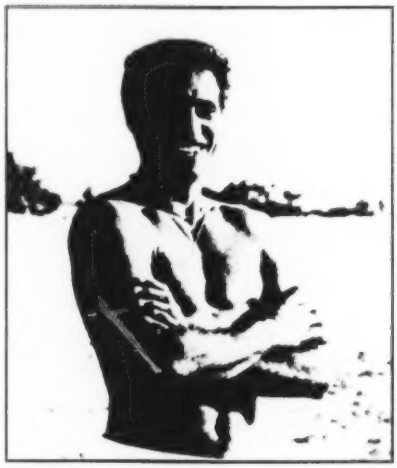
Brian L. Keaulana • *lifeguard*

current job: I work for the Hawaii Department of Parks and Recreation as a lifeguard supervisor on the west side of Oahu.

key factor: I grew up on the beach, where I was very active in ocean-related activities and experienced a range of extreme ocean conditions. I wanted to make use of my abilities and limitations as an open-water lifeguard.

like most: I enjoy educating people about environmental issues and sharing my skills in water sports and my knowledge of potential ocean hazards.

like least: It is frustrating when changes or improvements are necessary in the area of water safety and bureaucratic systems fail to understand or acknowledge the need. I spend a lot of my time trying to educate government officials about what is necessary for us to perform our jobs efficiently and effectively.



relax: I like to begin each day surfing, swimming, sailing, canoe surfing, diving, or doing something similar that involves the ocean. The ocean always gives me peace of mind. My favorite relaxation is to surf waves that are 20 feet or more because I enjoy the challenge of extreme surfing.

heroes/heroines: My heroes are the "nobodies," the people who become somebody because they have the willingness to learn and a positive attitude that keeps them focused, consistent, and drug free.

advice: Recognize that you are in the crossroads of your life. If a career in water safety is your goal, start working toward the smaller goals that will help you achieve the end result.

career opportunities: The potential in water safety is increasing because of the growth in the number of people seeking ocean recreation and the types of activities available. In addition, advancements in rescue techniques and equipment also provide more opportunities.

10 years: I will continue to be active in all water sport activities: surfing, swimming, sailing, jet skiing, etc. I also hope to remain involved in protecting and educating the people of Hawaii on ocean recreation and safety.

Gina G. Rogers • *fisheries statistician*

B.S., natural resources management, Univ. of Maryland

current job: I work for the Georgia Department of Natural Resources in Brunswick, Georgia, as fisheries statistics coordinator. I supervise three port agents and am responsible for the collection and dissemination of all commercial seafood landings and license statistics. I spend part of my time in the office working with the data on computers and part of my time in the field collecting landings data. My job also requires that I work on the docks with the commercial snapper/grouper fishermen measuring and weighing their fish and taking biological samples.

key factor: I have always enjoyed being outside. As a child I spent a great deal of time camping and fishing with my family. As I grew older, I became concerned about pollution and the destruction of important habitat for animals and the overall degradation of the environment. I decided that I wanted to work in an environmental field.

like most: I like being outdoors and being tested physically. You really stay in shape when you are pulling nets and scuba diving and doing field work. I also look forward to going to work every day and that is a nice feeling. Another bonus is getting to work hands-on with interesting animals. I have worked with bald eagles, condors, sea turtles, manatees, alligators, dolphins, and a wide variety of finfish and crustaceans.

like least: Biology is not a high paying career. As you progress with your career as a biologist, you must take on supervisory and administrative tasks in order to "climb the ladder" and make more money. As a result, you spend less time in the field and more time doing paperwork. You become a manager. The responsibility and the higher pay are nice but I really miss being outside.

relax: I try to get away for long weekends as much as I can. Sometimes I travel with my husband to competitive king mackerel fishing tournaments and fish with him off shore. Sometimes we go camping or canoeing. I enjoy antiquing, reading, and visiting friends.

heroes/heroines: The only well known person that I can think of is Ghandi.

advice: I would advise them to take their studies seriously and get A's and B's in their science and math courses. They should take as many biology, zoology, chemistry, physics, algebra, and calculus classes in high school as they can. They should get as much volunteer/intern experience as they can while in college. During the summers they should find jobs working as technicians at research field stations or laboratories or museums. In order to compete for jobs when they graduate, they will have to have experience.

career opportunities: I have spent my entire career working for federal and state governments (U.S. Fish & Wildlife Service, Smithsonian, University of Georgia, state of Georgia). Most biological/environmental research is dependent on funding from the federal government and from state governments. Job opportunities in the environmental sciences are deeply affected by budget cuts and appropriations on Capitol Hill. If Congress cuts programs that fund environmental research, many people lose their jobs. The field of biology is very competitive. In order to compete successfully, you need to have at least a master's degree and lots of work experience.

10 years: I'm not sure what I will be doing. I am pregnant with my first child and I am planning to stay home for five to seven years to be with my children. I will be working part time at home doing bookkeeping on a computer for a local business during that time. When my children are school age, I will go back to work full time. I might get my teaching license and teach biology or it is very possible that I will get back into fisheries research and management.

Carl T. Baker • *resource manager*

B.S., biology, Ohio Univ.

current job: I am an aquatic biologist for the Ohio Division of Wildlife at the Lake Erie Fisheries Research Unit, which is located in Sandusky. As station manager, I supervise fisheries research biologists and coordinate inventory/research/management projects with Lake Erie fisheries agencies in Michigan, New York, Pennsylvania, and Ontario.

key factor: My interests in fish and fisheries management.

like most: Taking inventory of changing fish populations, monitoring commercial and sport harvests, coordinating projects and management techniques with other Lake Erie fisheries agencies.

like least: Governmental red tape purchasing procedures.

relax: Sport fishing, small game hunting, and camping.

heroes/heroines: Aldo Leopold, who wrote ***A Sand County Almanac***. He is the "father" of watershed management. Good fisheries management begins with good land stewardship. Other heroes would include all those who continue to wade through our governmental procedures, sticking to their principles and feeling they can make a difference.

advice: Pursue higher education. Get hands-on experience. Learn how to deal with various systems of management. Become skilled in the use of computers. Learn to work with people.

career opportunities: Fisheries management positions are decreasing due to down scaling. Watershed management and environmental assessment positions are increasing due to the growing public concern for the environment.

10 years: I'll be retired, and spending my time hunting and fishing. I'll also be enjoying the fruits of my management efforts and/or recognizing how future resource management should be done differently.

Kurt Byers • *environmental communicator*

B.S., natural resources, Univ. of Michigan, Ann Arbor

current job: As communications manager of the University of Alaska (Fairbanks) Sea Grant College Program, I decide what kind of information will help people wisely use and conserve Alaska's marine resources, and I also decide how to package and distribute the information to a wide variety of people. My office produces books, pamphlets, newspaper and magazine articles, fact sheets, photographs, videos, radio programs, interpretive signs, exhibits and displays, presentations, and public events.

key factor: In returning to college at age 30 after a decade in private business, I decided to develop my creative talents — writing, photography, and art — and use those skills and my business sense in a career that would promote wise stewardship of our natural environment.

like most: As manager of the communications program, I have a lot of freedom to put my ideas into action and to decide what needs to be done to communicate useful information to our audiences.

like least: The day-to-day demands of managing a communications program prevent me from devoting as much time and effort as I would like to the hands-on creative aspects of communications, such as writing, photography, and graphic design.

relax: I relax by reading news magazines, newspapers, and an occasional techno-thriller novel. I also enjoy going to movies and plays, photographing or videotaping new places during my travels around the countryside, and exploring towns and cities. I also enjoy learning about and listening to various kinds of music, especially electric blues. I enjoy playing softball and golf, shooting baskets, and tossing the football. I recently began to equip myself for camping and fishing in Alaska.

heroes/heroines: My only real hero is my father, who, after surviving the perils of World War II as a decorated fighter pilot, teamed with my mother to build the house I grew up in, provide a stable and supportive environment for me and my four sisters, and instill a strong work ethic and compassionate social values. I also admire the countless anonymous people everywhere who do what they can to improve their part of the world.

advice: Develop analytical skills by always questioning why things are the way they are, and work on developing your ideas for improving the status quo. Develop strong writing skills, and take a heavy dose of the natural sciences. Develop your technical communications skills, with a special emphasis on computers and how they can be used to find, organize, and communicate information.

career opportunities: As long as people are concerned about conserving our marine environment, there will be a need for highly trained and motivated professional environmental communicators who can synthesize, translate, and disseminate important information about marine resources and the effects of human activity on these resources. But many people want jobs as professional communicators in the field of marine resources, so the better prepared you are, the better your chances are to find a good job in this field.

10 years: I expect I will be a communicator or educator in the field of natural resources, or perhaps teaching others how to become effective communicators.

Career Outlook

As you have seen in this guide, the marine field offers many job choices. In addition, the field is always changing. What may be a "hot" job today could be a tough field to get into when you graduate. This field, like many others, is influenced by hard-to-predict factors. Be persistent and explore all of your options.

As you may have discovered, job trends and predictions tend to vary dramatically within the marine science fields. Don't let these predictions make your career choice for you. It is important to consider who is making the predictions and what these predictions are based on. For example, employment trends within the private sector (business and industry) may vary greatly from the opportunities available within the public sector (universities and government). Likewise, asking a scientist about the job outlook in his or her field may get you a different answer than had you asked the same question of a non-scientist, and so on.

Research Careers

Students interested in pursuing a research career may find opportunities in academia, industry, government, non-profit and non-governmental organizations, consulting firms, and owning their own businesses. Many factors influence job opportunities in these areas, including the economy, funding, and distribution of government support.

Changes in government research funding have clearly impacted the research community. The pendulum swinging between support for basic research on one side and more "applied" or solutions-oriented research on the other can jeopardize entire laboratories and facilities. Politics can affect the research community as well. In times of decreased federal support for research (both financial and political), there is greater pressure to find support from other sources, such as private industry and philanthropic foundations.

Researchers in Academia

If you were to ask a spokesperson from a major research university about the outlook for a research career a decade ago, the response, in most cases, would have been that there will be plenty of options for master's or doctorate level graduates in marine research and teaching. Today, the answer would be more complicated.

Whereas a career at a university was once considered the traditional route — and one that students aspired to — changes in the academic world, coupled with funding uncertainties, have made this career path far less predictable but still exciting and worthy of consideration, according to Dr. John Farrington, dean of Graduate Studies at the Woods Hole Oceanographic Institution (WHOI), one of the world's largest private, non-profit marine research organizations.

A study on graduate education of scientists and engineers, commissioned by the National Academy of Sciences (NAS), found that while Ph.D. graduates are finding jobs, "they are finding non-academic jobs more easily than they are finding academic research positions." The findings do not come as a surprise. As the final report states, "cuts in defense spending, restructuring in industries, and slower growth in federal R&D spending have altered the market for scientists and engineers."

Dr. Harold Varmus, director of the National Institutes of Health (NIH), reports that graduates of NIH-sponsored programs "are finding employment in 'nontraditional' occupations — patent law, science policy and administration, the media, investment firms, and novel educational settings." He said there has been a growth of employment in medical research industries including biotechnology, research supplies, and pharmaceutical companies.

Dr. Neal Lane, director of the National Science Foundation (NSF), sponsored a workshop on graduate and postdoctoral training. The workshop revealed that "unemployment and underemployment (taking a position where one's educational qualifications exceed those required by the position) rates vary significantly across fields, with engineers and life scientists generally faring better than physicists, sociologists, and geoscientists."

Employment figures for Ph.D. graduates in the academic sector may be somewhat misleading. Dr. Ned Heindel of Lehigh University cautions against taking Ph.D. employment figures at face value. "Employment figures for Ph.D.s look good," he explained, "due to the 'great postdoc buffer' soaking up graduates."

Figures compiled by Dr. Arthur Nowell, director of the School of Oceanography at the University of Washington, seem to reinforce this scenario. 1993 statistics reveal a 67% employment rate for Ph.D. graduates in the university sector, which includes postdoctoral appointments. In

a best-case scenario, postdoctoral appointments last only for a couple of years. Today, many Ph.D. graduates continue to serve as postdocs many years after receiving their degrees because the research jobs in academia are harder to come by.

Within an academic setting, there are basically three possibilities for employment: research and training, teaching and research, and teaching and modest research. According to Farrington, the good news is that "colleges and their students will always need professors." In fact, he said, job opportunities at the community colleges and smaller private and public universities and colleges show a modest increase for several oceanographic disciplines.

Researchers in Industry

Research careers in industry are very diverse, and "industry" is difficult to characterize. Nicholas Basta, in his 1992 book ***Environmental Jobs for Scientists and Engineers***, writes, "in the overall job market, there has been a trend among Ph.D. scientists and engineers toward working in industry and a corresponding decline to their working in academia. . . The grand summation of these trends is that the scientific enterprise is becoming increasingly interwoven with the economic enterprises of the United States."

"Industry positions can be very heterogeneous," says Dr. Jay W. Gooch, an environmental scientist with Procter and Gamble. In his position, Gooch helps provide the company with the tools and expertise necessary to ensure that its products are safe. Prior to his industry job, Gooch had experience in academia — first at WHOI and later at the University of Maryland.

"While some people find careers in industry that are hard to distinguish from an academic career — that is, mostly research — others find a blend of research and product-oriented problem-solving and management," says Gooch. Also common in industry: "research positions that mostly involve conducting standardized tests and very little in-house research."

And, as is the case with many companies, there may be virtually no R&D; instead, companies rely on existing technologies to make products.

Some of the biggest opportunities for research careers in industry exist within environmental departments and R&D divisions of large corporations, as is the case with Gooch's position. For industries such as pharmaceuticals, construction, manufacturing, energy production, and resource exploration and development, scientists and engineers provide important data to company managers. This research can be used to create new products, improve existing products, or discontinue ineffective products.

Students interested in pursuing a research career may find opportunities in academia, industry, government, non-profit and non-governmental organizations, consulting firms, and owning their own businesses.

According to Gooch, "most environmental researchers in industry do research that 'supports' product development. This support is achieved by conducting the tests that are necessary to demonstrate that products can be used safely."

Within industry, research is most valued for its ability to develop new products or improve existing products. Improvement is generally measured by the product's ability to increase sales and boost profits while keeping production costs low. "Product success in the marketplace," says Gooch, "is the fuel that drives the research and development engine."

One characteristic of industry is the fact that it can be dependent on external factors such as the economy and consumer-driven market demand. Other characteristics of industry research careers are regular hours (there are exceptions) and the importance of teamwork.

Because teamwork is important, communication skills and the ability to relate to and interact with peers are highly valued by employers. "Unlike many independent academic researchers, successful industry scientists have a strong focus on 'what's best for the company,'" said Gooch.

Other opportunities exist for marine scientists and oceanographers in non-traditional private industry, outside the realm of R&D. For example, insurance companies rely on the science of oceanographers to predict and understand weather-related hazards and natural disasters. Transportation-related industries, such as airlines and shipping companies, also rely on advances in oceanography and engineering — such as weather forecasting and navigation technologies — to run their businesses efficiently and safely.

Researchers in Government

As with research jobs in industry, those in government are difficult to generalize. Jobs for scientists and engineers exist in government research labs or departments and in areas such as policy and management. These jobs exist at the federal, state, and local levels. With the current push to downsize the federal government, many believe that opportunities at the city, local, and state government levels will increase, while federal opportunities will decrease.

Being a government scientist differs from being a scientist employed by a university or private research facility. Dr. Kathryn Sullivan, chief scientist at the National Oceanic and Atmospheric Administration (NOAA), describes the difference as a trade-off.

"Government scientists," said Sullivan, "perform research that is relevant to the missions of their agencies. While this research may still be in areas of fundamental science, the agency must be able to envision an eventual societal benefit and may sometimes require the individual to direct his or her inquiries in a certain field. In return for this, government scientists are granted certain freedoms, most notably a certainty that they will indeed by employed in research."

Dr. Steve McCormick, a research physiologist with the National Biological Service of the U.S. Department of the Interior, agreed. "Certainly, a characteristic that differentiates government research jobs from jobs in academia is not always needing to write grants to secure funding. But, on the down side, you don't have the freedom to pursue your real research interests because you're often constrained by the agency needs."

McCormick adds that the emphases of government agencies can change frequently as the government responds to changing research needs. He cites the NIH as a symbol of success in government-sponsored research. "The core mission of NIH has remained the same over the years, but individual focus areas and priorities change all of the time — this is necessary and important."

In addition to his government position, McCormick has an affiliation with a university, a combination he considers a real benefit. Such an affiliation, which can involve teaching and advising students, is generally feasible for government researchers and is fairly common.

Researchers in Non-profit and Non-governmental Organizations

Non-profit and non-governmental organizations provide additional career options for scientists and engineers, in addition to the many opportunities they offer non-researchers. Examples of such organizations include the Nature Conservancy, the World Wildlife Foundation, Greenpeace, the Sierra Club, and lesser known organizations like the Woods Hole Research Center (a group that conducts research and fundraising on topics such as biodiversity and deforestation in Brazil and the former Soviet Union) and the Monterey Bay Aquarium Research Institute (a half science, half engineering institute that develops instruments, systems, and methods for scientific studies of the deep ocean and specializes in exploration with remotely operated vehicles).

Because there are so many non-profit and non-governmental organizations, there are many choices in terms of specialty area, size, and geographic location. A concern for many in these sectors is funding pressure and competition, the relatively small number of pure research positions available, and the salaries, which tend to be lower than in industry or academia. Many of these organizations take on advocacy roles in support of various causes or policies. Some are active in political circles as well, testifying before Congress about issues that involve governmental policies or regulations.

Researchers in Consulting Firms or Private Enterprise

Environmental consulting is another career option. Consulting companies range in size and scope from large, international, multi-specialty firms to small companies specializing in one field. Consulting careers have offered researchers many opportunities in the past. Whether or not this trend will continue is hard to predict. The field is highly competitive and, as such, often requires competent presentation skills.

An increasingly attractive option for many scientists and engineers is starting a business. This allows for flexibility and may be a way to combine a part-time teaching position with independent research and "research for hire." On the down-side, one should be willing to put in long hours and a fair amount of unpaid work in order to get established.

Summary

In addition to being good scientists and engineers, today's researchers must also be good writers and speakers. These requirements come from the need for researchers to submit proposals to funding sources in an attempt to get financial support for their research. Likewise, presenting the results of one's research — to colleagues, decision-makers, students, and funding sources — is important. And, as stressed throughout this guide, it is important to have a basic understanding of all the major disciplines of oceanography.

Non-Research Careers

A research career is certainly not the only option for students interested in the exciting field of marine science. In fact, the possibilities for a non-research career are as varied as one's desires and imagination.

Unfortunately, changes in the economy and politics can impact non-research marine careers in much the same way they impact the research community. For example, less federal support for education often means less support for state education programs. In time, the cuts reach the small, community-based programs such as after-school science clubs, science museums, and nature facilities as well as educational programming on science or the environment.

Recent shifts in the U.S. economy — away from the defense industry, primary manufacturing, and natural resource mining, and toward the industry and service sectors — have created new demands and skill requirements for the U.S. workforce. What will this mean for students interested in a marine-related career? For one thing, more opportunities in the information and mass communication sectors seem likely, as do opportunities in marine industries, such as marine electronics, aquaculture, recreation and tourism, engineering, hydrogeology, water quality management, and environmental education and communication.

And, as WHOI's Farrington points out, "a quality existence and progress for humanity will continue to be dependent on advancing knowledge of our habitat and using that knowledge wisely."

Additional Resources

Organizations

American Society of Limnology and Oceanography — A nonprofit, professional scientific society that seeks to promote the interests of limnology and oceanography and related sciences and to further the exchange of information across the range of aquatic science disciplines. C. Susan Weiler, Whitman College, Walla Walla, WA 99362

Association for Women in Science — A nonprofit association dedicated to increasing the educational and employment opportunities for both girls and women in all fields of science. 1522 K St., Suite 820, Washington, DC 20005, 202/408-0742, fax: 202/408-8321, e-mail: awis@access.digex.net

Center for Marine Conservation — A nonprofit membership organization dedicated to protecting marine wildlife and its habitats and to conserving coastal and ocean resources. 1725 DeSales St., NW, Washington, DC 20036

The Cousteau Society — A nonprofit environmental education organization dedicated to the protection and improvement of the quality of life for present and future generations. 870 Greenbrier Circle, Suite 402, Chesapeake, VA 23320

Marine Technology Society — An international, interdisciplinary society devoted to ocean and marine engineering science and policy. 1828 L St., NW, Suite 906, Washington, DC 20036-5104, 202/775-5966, fax: 202/429-9417

National Marine Educators Association — An organization for those interested in the study and enjoyment of the world of water — both fresh and salt. PO Box 51215, Pacific Grove, CA 93950, 408/648-4837, fax: 408/648-4837, e-mail: mrigsby@mbayaq.org

National Oceanic and Atmospheric Administration — A government agency that guides use and protection of our oceans and coastal resources, warns of dangerous weather, charts the seas and skies, and conducts research to improve our understanding and stewardship of the environment. NOAA Correspondence Unit, 1305 East-West Highway, #8624, Silver Spring, Md. 20910

National Science Foundation — An independent agency of the federal government established in 1950 to promote and advance scientific progress in the United States. NSF Office of Legislative and Public Affairs, Rm. 1245, 4201 Wilson Blvd., Arlington, VA 22230, 703/306-1070, fax: 703/306-0157

Oceanic Engineering Society — An organization that promotes the use of electronic and electrical engineers for instrumentation and measurement work in the ocean environment and the ocean/atmosphere interface. Norman D. Miller, 2644 NW Esplanada Dr., Seattle, WA 98117-2527, phone/fax: 206/784-7154, e-mail: n.miller@ieee.org

The Oceanography Society — A professional society for scientists in the field of oceanography. 4052 Timber Ridge Drive, Virginia Beach, VA 23455, 804/464-0131, fax: 804/464-1759, e-mail: jrhodes@ccpo.odu.edu

Office of Naval Research — A component of the U.S. Navy, ONR plans, fosters, and encourages scientific research and technology development in recognition of their paramount importance to national security. ONR Public Affairs Office, 800 North Quincy St., Arlington, VA 22217, 703/696-7034, fax: 703/696-5940

The Society for Marine Mammalogy — A professional organization that supports the conservation of marine mammals and the educational, scientific, and managerial advancement of marine mammal science. Daniel K. Odell, SMM Education Committee, Sea World, 7007 Sea World Drive, Orlando, FL 32821-8097, 407/363-2662, fax: 407/345-5397, e-mail: odell@pegasus.cc.ucf.edu

Publications

Careers in Oceanography and Marine-Related Fields — available from The Oceanography Society

Education and Training Programs in Oceanography and Related Fields — $6, available from the Marine Technology Society

Strategies for Pursuing a Career in Marine Mammal Science ($1.50 for students, $3 for others) — Allen Press, P.O. Box 1897, Lawrence, KS 66044-8897, 800/627-0629

Taking the Initiative: Report on a Leadership Conference for Women in Science and Technology — available from the Assoc. for Women in Science

You Can Teach Science (high school version) — available from the Office of Public Information, National Science Teachers Assoc., 1840 Wilson Blvd., Arlington, VA 22201, 703/243-7100

Note — The organizations and publications listed here are but a sampling of the resources that are available to help you learn more about careers in the marine sciences. Each contact you make in your search for information will lead you to more contacts and more information.

Sea Grant Programs

ALABAMA
(see Mississippi)

ALASKA
Alaska Sea Grant
Univ. of Alaska
P.O. Box 755040
Fairbanks, AK
99775-5040
907/474-7086

CALIFORNIA
California Sea Grant
Univ. of California
-San Diego
9500 Gilman Dr.
La Jolla, CA 92093-
0232
619/534-4446

Southern California
Sea Grant
Hancock Institute
for Marine Studies
University Park
Los Angeles, CA
90089-0373
213/740-1961

CONNECTICUT
Connecticut Sea Grant
Univ. of Connecticut
1084 Shennecossett
Rd.
Groton, CT 06340
203/445-3457

DELAWARE
Delaware Sea Grant
Univ. of Delaware
Robinson Hall,
Room 111
Newark, DE 19716
302/831-2841

FLORIDA
Florida Sea Grant
Univ. of Florida
Box 110400
Gainesville, FL 32611
904/392-5870

GEORGIA
Georgia Sea Grant
Univ. of Georgia
Room 13, Ecology
Building
Athens, GA 30602-
2206
706/542-6009

HAWAII
Hawaii Sea Grant
Univ. of Hawaii
1000 Pope Rd.,
Room 223
Honolulu, HI 96822
808/956-7031

ILLINOIS
Illinois-Indiana Sea
Grant
Univ. of Illinois
51 Mumford Hall
1301 W. Gregory Dr.
Urbana, IL 61801
217/333-8055

INDIANA
Illinois-Indiana Sea
Grant
Purdue Univ.
Dept. of Forestry and
Natural Resources
1159 Forestry Bldg.
W. Lafayette, IN
47907-1159
317/494-3573

LOUISIANA
Louisiana Sea Grant
Louisiana State Univ.
128 Wetland
Resources
Baton Rouge, LA
70803-7507
504/388-6710

MAINE
Maine/New Hampshire
Sea Grant
Univ. of Maine
5715 Coburn Hall,
Room 21
Orono, ME
04469-5715
207/581-1440

MARYLAND
Maryland Sea Grant
Univ. of Maryland
0112 Skinner Hall
College Park, MD
20742
301/405-6371

MASSACHUSETTS
MIT Sea Grant
Massachusetts Insti-
tute of Technology
Bldg. E38, Room 300
77 Massachusetts Ave.
Cambridge, MA 02139
617/253-7041

WHOI Sea Grant
Woods Hole Oceano-
graphic Institution
193 Oyster Pond Rd.,
CRL 209
Woods Hole, MA
02543-1525
508/289-2665

MICHIGAN
Michigan Sea Grant
Univ. of Michigan
2200 Bonisteel Blvd.
Ann Arbor, MI
48109-2099
313/764-1138

MINNESOTA
Minnesota Sea Grant
Univ. of Minnesota,
Duluth
2305 E. 5th St.
Duluth, MN 55812
218/726-8106

MISSISSIPPI
Mississippi-Alabama
Sea Grant
Consortium
P.O. Box 7000
703 East Beach Dr.
Ocean Springs, MS
39564
601/875-9341

NEW HAMPSHIRE
Maine/New Hampshire
Sea Grant
Univ. of New
Hampshire
Kingman Farm
Durham, NH
03824-3512
603/749-1565

NEW JERSEY
New Jersey Sea Grant
NJ Marine Sciences
Consortium
Building No. 22
Ft. Hancock, NJ
07732
908/872-1300

NEW YORK
New York Sea Grant
Institute
State Univ. of New
York
115 Nassau Hall
Stony Brook, NY
11794-5001
516/632-6905

NORTH CAROLINA
North Carolina Sea
Grant
Box 8605, North
Carolina State Univ.
Raleigh, NC
27695-8605
919/515-2454

OHIO
Ohio Sea Grant
Ohio State Univ.
1541 Research Center
1314 Kinnear Rd.
Columbus, OH 43212
614/292-8949

OREGON
Oregon Sea Grant
Oregon State Univ.
Admin. Services,
A500 G
Corvallis, OR
97331-2131
503/737-2714

PUERTO RICO
Puerto Rico Sea Grant
Univ. of Puerto Rico
P.O. Box 5000
Mayaguez, PR
00681-5000
809/834-4726

RHODE ISLAND
Rhode Island Sea
Grant
Univ. of Rhode Island
Narragansett Bay
Campus
Narragansett, RI
02882-1197
401/792-6842

SOUTH CAROLINA
South Carolina Sea
Grant Consortium
287 Meeting St.
Charleston, SC 29401
803/727-2078

TEXAS
Texas Sea Grant
Texas A&M Univ.
1716 Briarcrest Dr.,
Suite 603
Bryan, TX 77802
409/862-3767

VIRGINIA
Virginia Sea Grant
Virginia Graduate
Marine Science
Consortium
Madison House
170 Rugby Rd.
Charlottesville, VA
22903
804/924-5965

WASHINGTON
Washington Sea Grant
Univ. of Washington
HG-30
3716 Brooklyn Ave.,
N.E.
Seattle, WA
98105-6716
206/543-6600

WISCONSIN
Wisconsin Sea Grant
Institute
Univ. of Wisconsin-
Madison
1800 University Ave.
Madison, WI 53705-
4094
608/262-0905

National Sea Grant College Program
National Oceanic and Atmospheric
Administration
SSMC3 Room 11606
1315 East-West Highway
Silver Spring, MD 20910
301/713-2431

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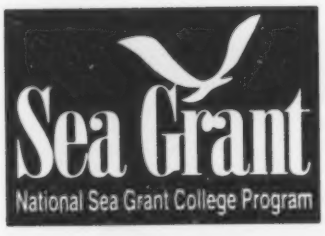
Sea Grant
National Sea Grant College Program

NOAA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE